Belle Physics Prospects

Eric Prebys, Princeton University

for the

Belle Collaboration

200 People

50 Institutions

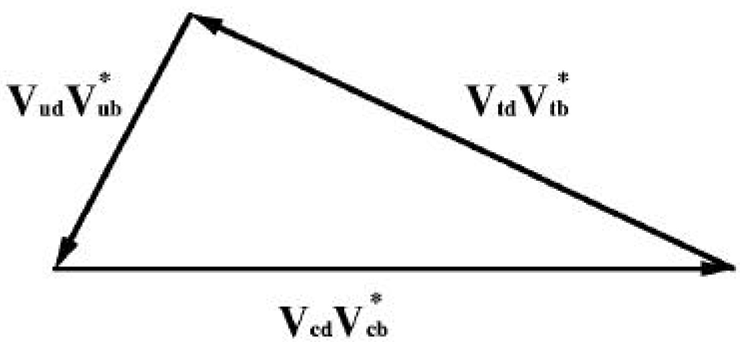
10 Countries

Outline

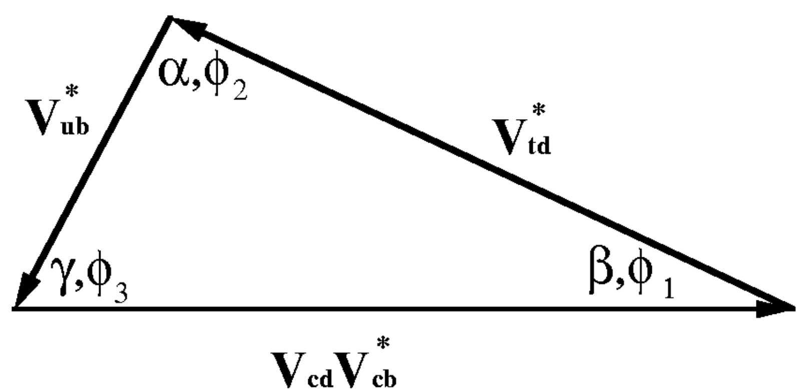
- Long Term Physics Goals (30-100 fb^{-1})
  - Indirect CP Violation
  - Direct CP Violation
  - Determination of CKM Elements
- Near Term Physics Goals (1-2 fb^{-1})
  - Preliminary ϕ_1 measurement
- Analyzing the Current Data Set
  - Our event sample.
  - Tagging J/ψ
  - Tagging K_L
  - Our First $B \rightarrow J/\psi\ K_L$ Event??

CP Violation

- Of the many unitarity triangles in the CKM matrix, the one which lends itself most readily to study is:

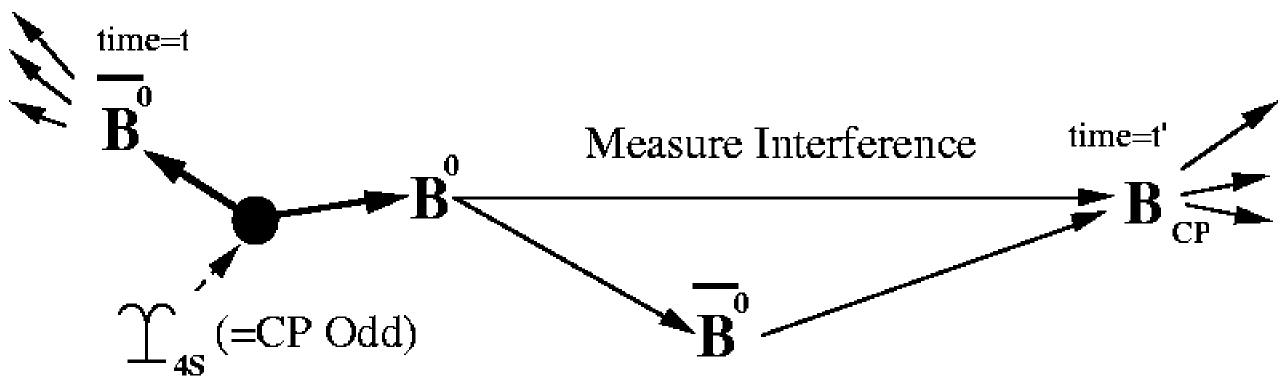


Simplify with $V_{ud} \approx V^*_{tb} \approx 1$ and $V_{cd}V^*_{cb}$ real $\Rightarrow$



Indirect CP Violation

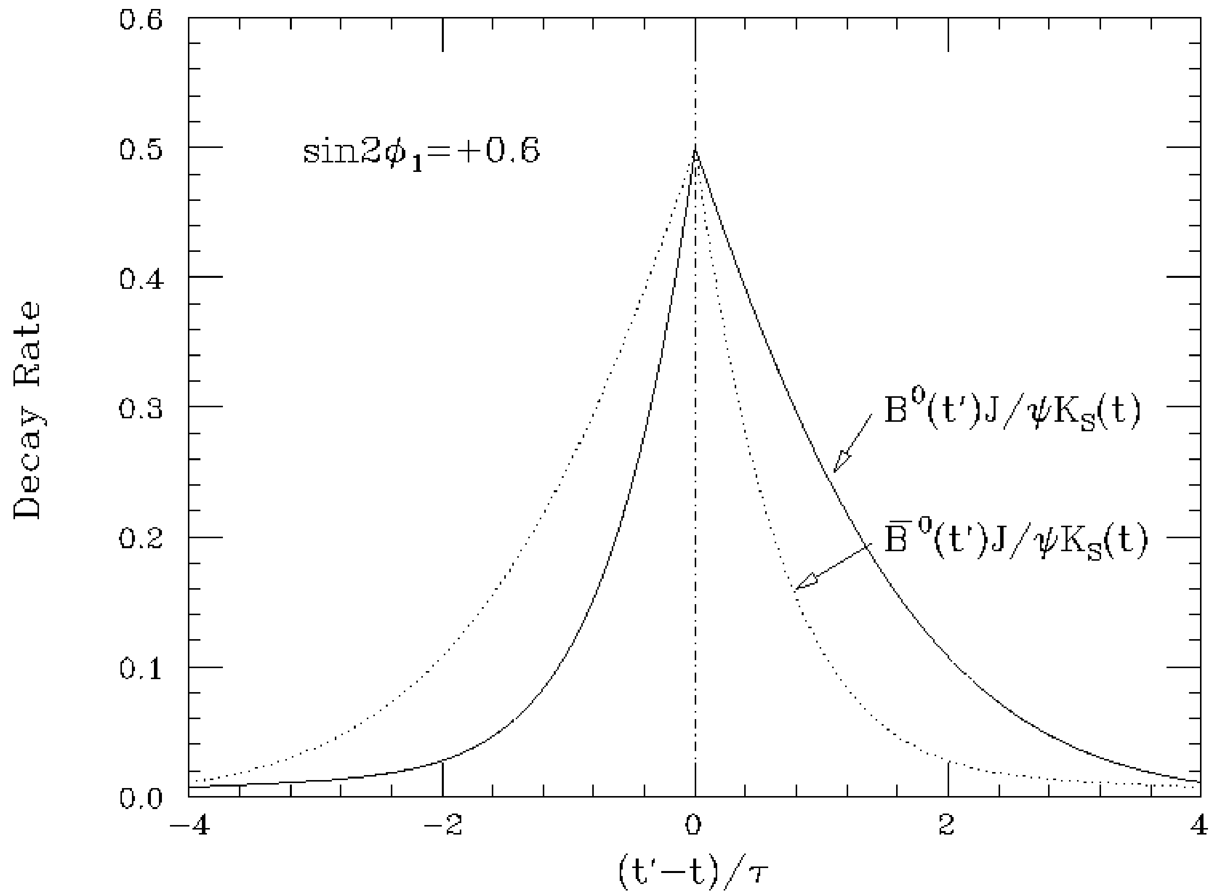
- We look study neutral B's decaying to CP eigenstates, and thus measure the interference which arises from mixing



- This is sensitive to the *difference* between the mixing phase and the decay phase

- We measure a time dependent asymmetry between

$$B \rightarrow (\text{CP eigenstate}) \text{ and } \overline{B} \rightarrow (\text{CP eigenstate})$$



Canonical Decay Modes

- ϕ_1
  - $B \to \psi K_S$
    - Straightforward
- ϕ_2
  - $B \to \pi\pi$
    - Must distinguish from $B \to K\pi$ and $B \to KK$
    - Poluted by penguin contribution
- ϕ_3
  - $B_s \to \rho\ K_S$
    - Require move to Υ(5s) resonance (messier)
    - Time dependent B_s mixing not possible.

ϕ_1 Measurement (100 fb^{-1})

- Should be straightforward
- Assume a dilution factor of .54 and a tagging efficiency of .308

Mode	**Nsignal**	**Nrecon**	**$\delta(\sin 2\phi_1)$**
$B \to \psi K_s^{+-}$	3640	1700	.075
$B \to \psi K_s^{00}$	1640	300	.20
$B \to \psi K_L$	5280	1100	.19

ϕ_2 Measurement (100 fb^{-1})

- Requires particle ID to distinguish $B\to\pi\pi$ from $B\to K\pi$ and $B\to KK$
- Polluted by penguin contributions

Mode	**Nsignal**	**Nrecon**	**$\delta(\sin2\phi_1)$**
$B\to\pi\pi$	1495	302	.15
$B\to\rho\pi$	Under study		

Direct CP Violation (ϕ_3 Measurement)

- Basic idea

$$B \rightarrow D^0 K = A_D e^{ip}$$

$$B \rightarrow \overline{D}^0 K = A_{\overline{D}} e^{iq} e^{i\phi_3}$$

- By doing a detailed study of D CP eigenstates

$$D_{1,2} \equiv \frac{D \pm \overline{D}}{\sqrt{2}}$$

we can get a measurement of ϕ_3 to 10 degrees or so.

CKM Elements

- V_{cb}
  - Study with $B \rightarrow D^* l \nu$
    - Statistical uncertainty 2×10^{-3}
    - Systematic uncertainty ?
- V_{ub}
  - Study with $B \rightarrow \pi l \nu$.
- V_{tb}
  - Study with B mixing.

The Near Future

- Our ultimate physics goals assume 100 fb^{-1}
  - This is 1 year @ 10^{34} $cm^{-2}s^{-1}$.
  - At this point $\sigma(\sin 2\phi_1) \approx .1$ or better from $B \to \psi K_S$.
- What about 1 fb^{-1}?
  - This is 1 month @ 10^{33} $cm^{-2}s^{-1}$.
  - Probably not too far away.
  - At this point, should have a handful of ψK_S .
  - Our $\sigma(\sin 2\phi_1)$ measurement begins to compete with CDF.

The Present

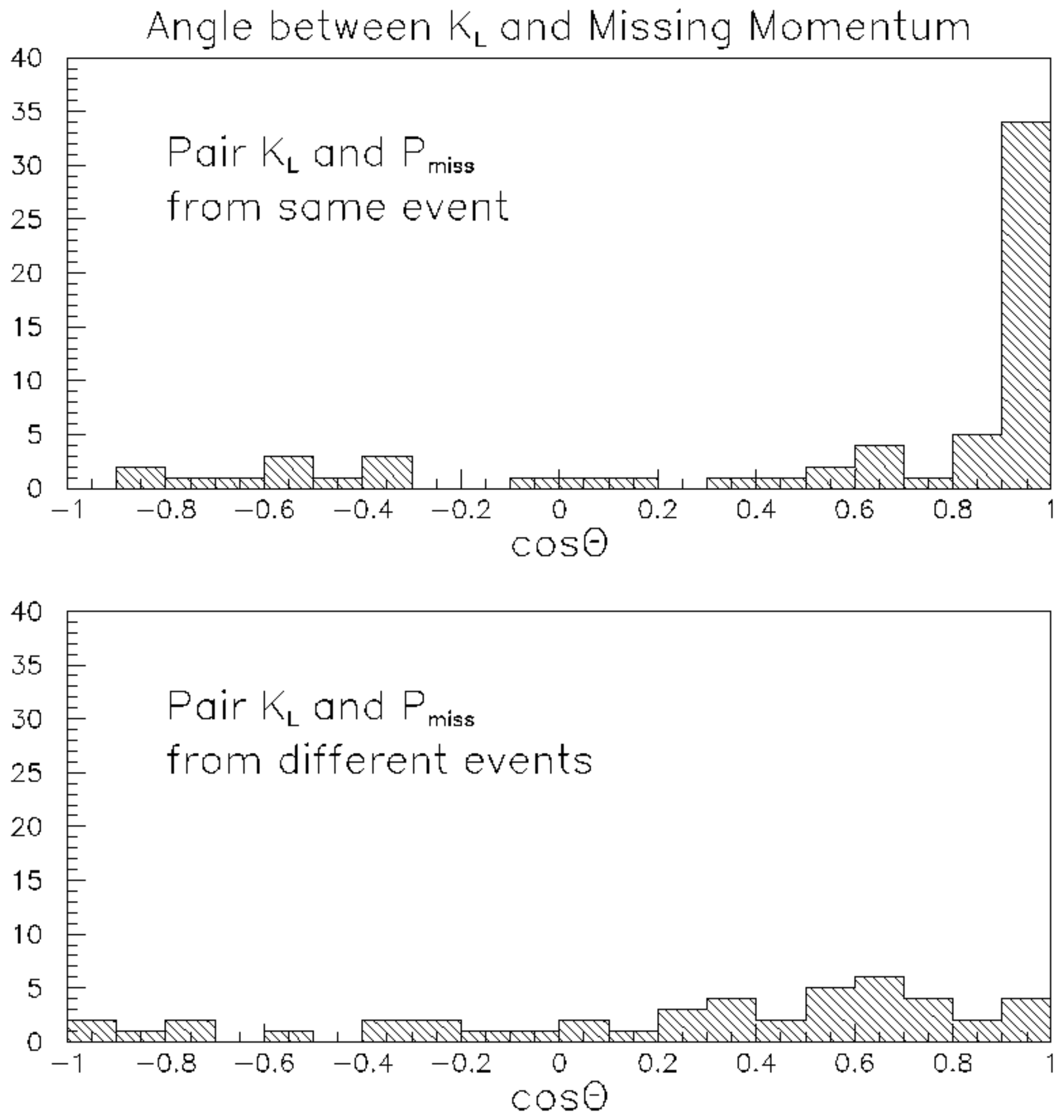
- Hadron A (loose)
  - # of good tracks >= 3
  - visible energy (tracks + ECAL clusters) > .2*Ecm
  - .025*Ecm< neutral ECAL < .9*Ecm
  - |pz(obs)| < .5*Ecm
    - ⇒7905 Events (lots of beam backgrounds)
- Hadron C (tight)
  - # of good tracks >=5
  - visible energy > .5*Ecm
  - .025*Ecm < neutral ECAL < .9*Ecm
  - |pz(obs)|< .3*Ecm
    - ⇒1390 Events (≈1 pb^{-1})

J/ψ Finding

- Electron Identification
  - Identify a charged track
  - Find associated ECL cluster with reasonable E/p
- Muon Identification
  - Identify charged track.
  - Find associated track segment in KLM
  - Likelihood calculated based in matching and penetration depth.
- Form e and μ pairs and look for mass consistent with J/ψ .

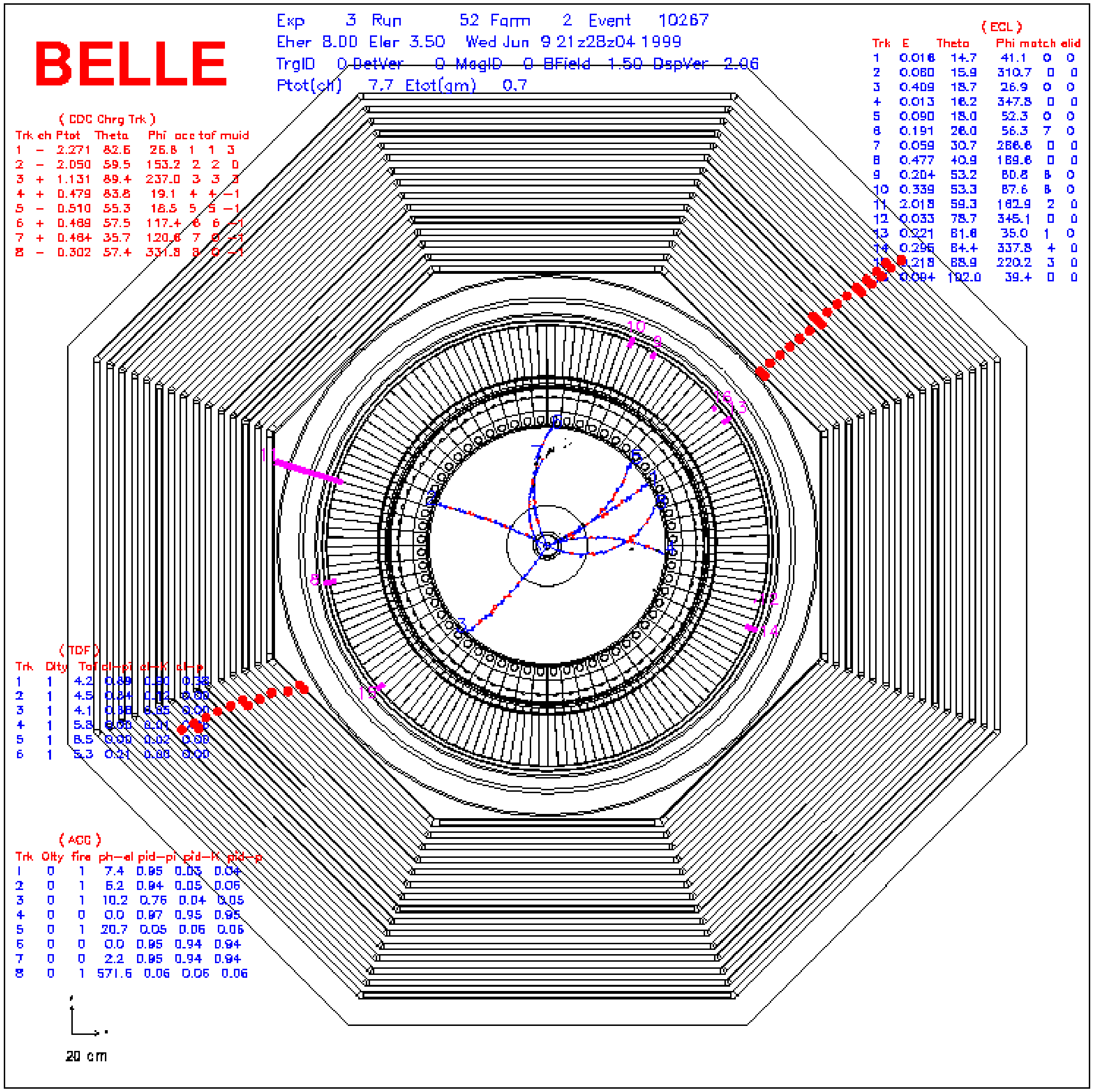
$\Rightarrow$ about 3 candidates

Can We Really See K_L's



- Cuts
  - At least on K_L Candidate
  - P_{miss}>1.25 GeV
  - $|\cos(\theta_{miss})|<.85$

Our Most Exciting Event (so far)



- Muon cuts
  - Associated KLM track segment.
  - Consistent range
- Dimuon mass cut
  - M(μμ)=3.1 GeV
- K_l cluster found
  - consistent with missing momentum.

But…

- P_{cm}(B) = .94 GeV
  - probably too high