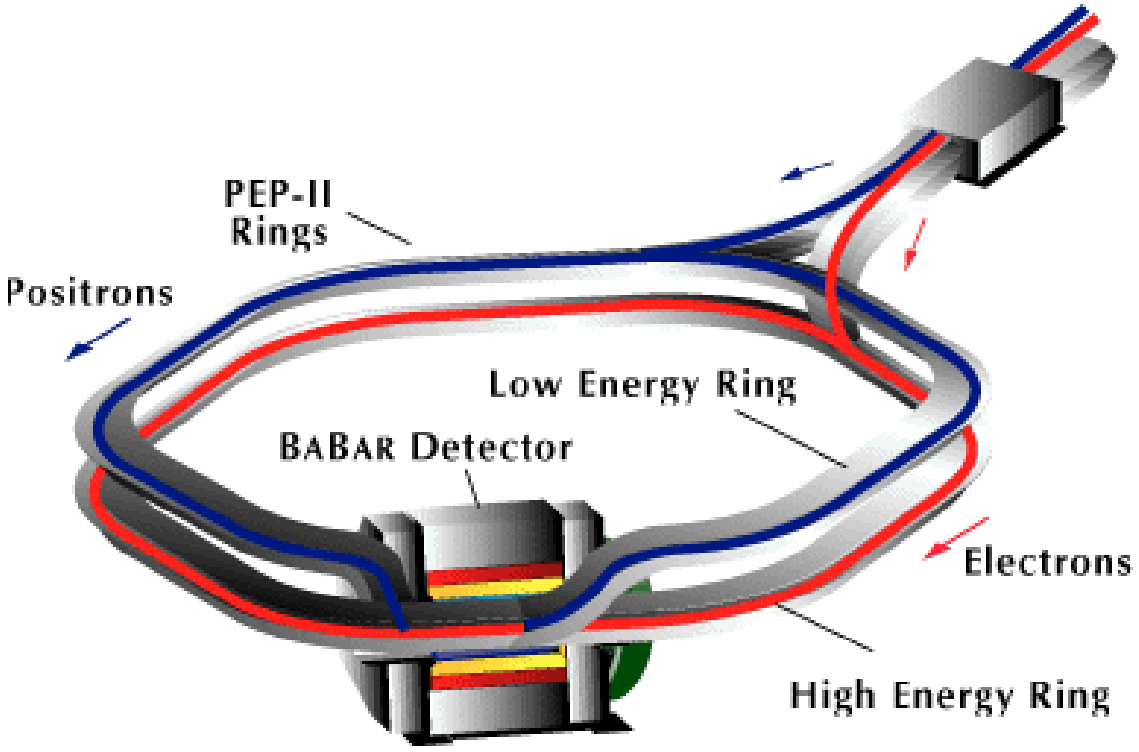
First Year of BABAR/PEP-II

— Measuring CP Violation at an Asymmetric B Factory —



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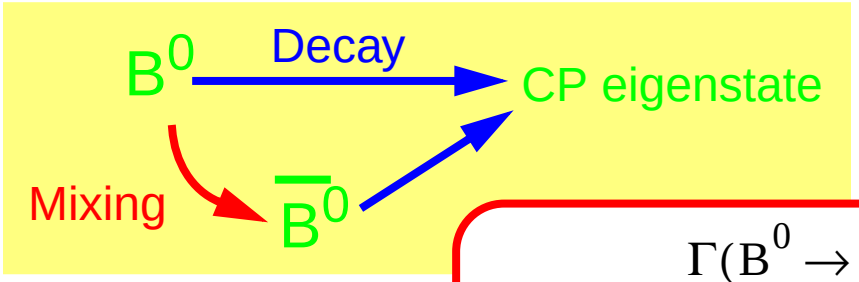
CP Violation in B^0 Decays

CP violation has been known for 36 years

- Occurs *naturally* in the Standard Model ← the CKM matrix
- Limited experimental constraints from K_L decays

→ Is CP violation fully explained by the Standard Model?

CP violation in B^0 decays comes to the rescue



- Interference between direct and mixed decays produces time-dependent CP asymmetry

t = decay time

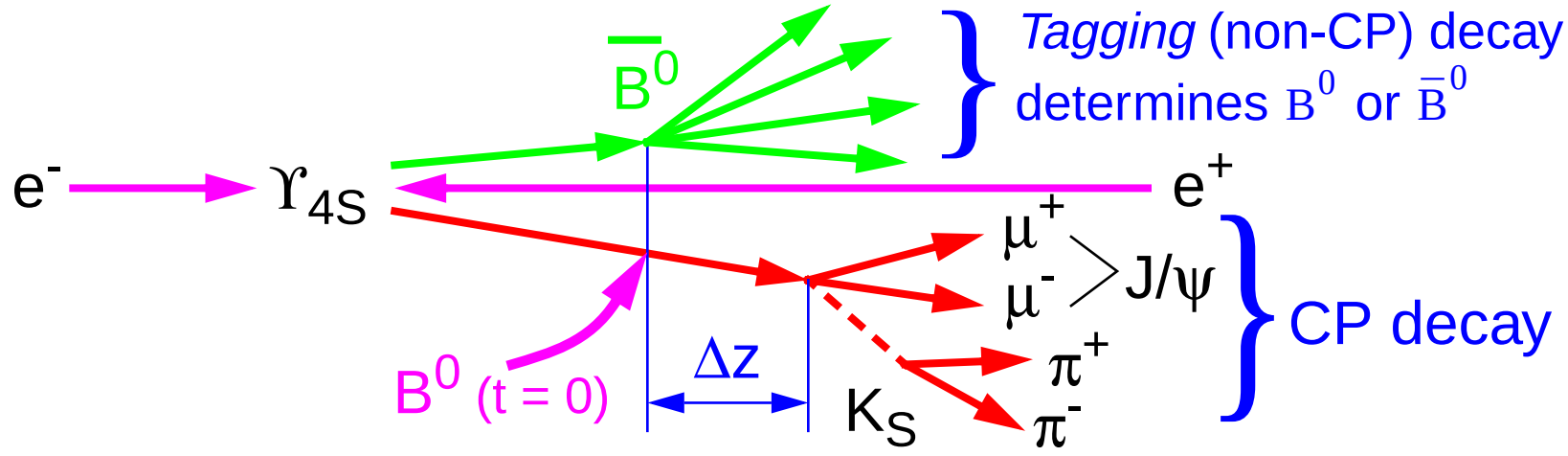
$$A_{CP}(t) = \frac{\Gamma(B^0 \to f_{CP}) - \Gamma(\bar{B}^0 \to f_{CP})}{\Gamma(B^0 \to f_{CP}) + \Gamma(\bar{B}^0 \to f_{CP})} = A_{CP} \sin(\Delta m \cdot t)$$

Asymmetry A_{CP} is related to the CKM angles α, β, γ

- E.g. $A_{CP} = \sin 2\beta$ for $B^0 \to J/\psi K_S$ (gold-plated decay)

→ Powerful probe to verify/disprove the SM prediction

How We Measure CP Violation



$$A_{CP}(t) = \frac{\Gamma(B^0 \to f_{CP}) - \Gamma(\overline{B}^0 \to f_{CP})}{\Gamma(B^0 \to f_{CP}) + \Gamma(\overline{B}^0 \to f_{CP})} = A_{CP}\sin(\Delta m \cdot t)$$

Step 1: Reconstruct a CP decay (e.g. $B^0 \to J/\psi\, K_S$)

- ✶ Low BR (5×10^{-5}) → luminosity & detector efficiency

Step 2: Tag the flavor of the other B^0

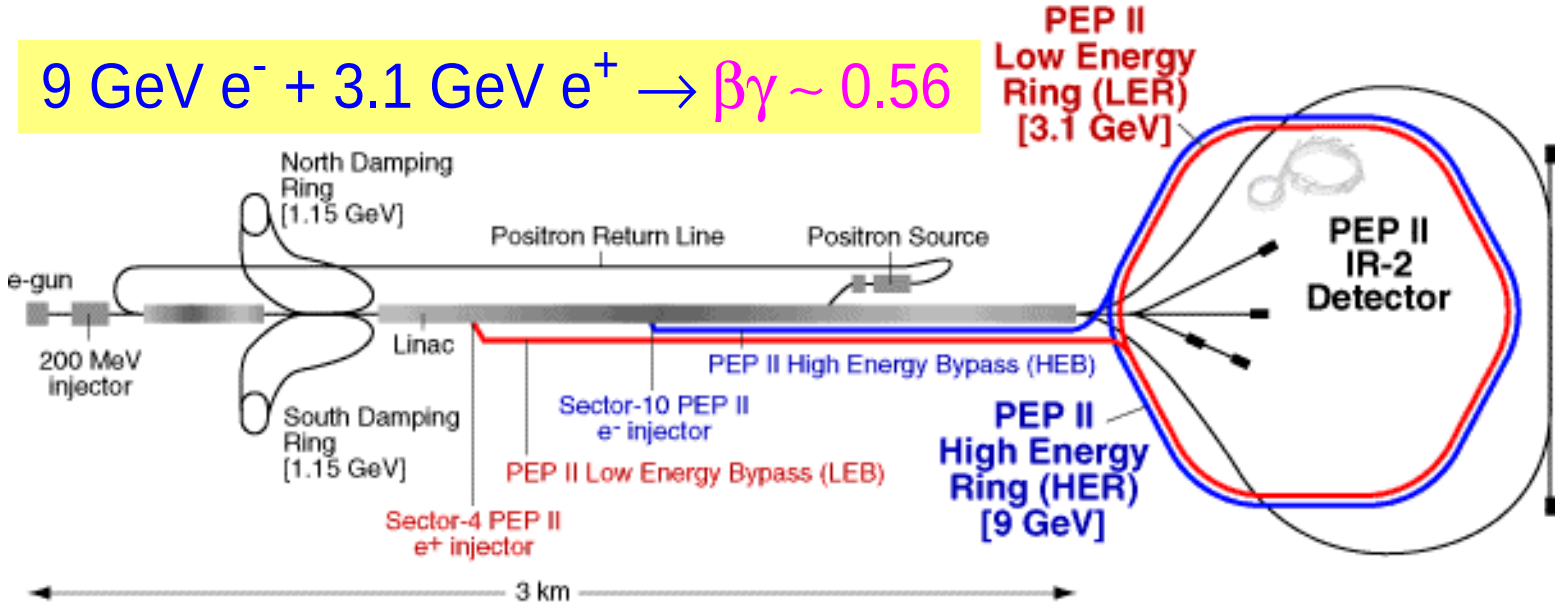
- ✶ Leptons and kaons → particle identification

Step 3: Measure $\Delta z \to t = \Delta z/\beta\gamma c$

- ✶ Asymmetric collider ($\beta\gamma = 0.56$)
- ✶ Vertex resolution → silicon vertex tracker

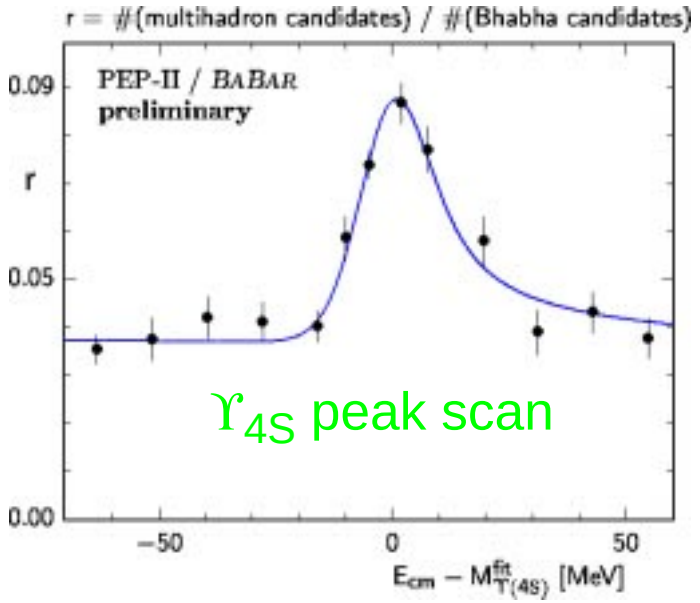
PEP-II Storage Ring

9 GeV e^- + 3.1 GeV e^+ → $\beta\gamma \sim 0.56$



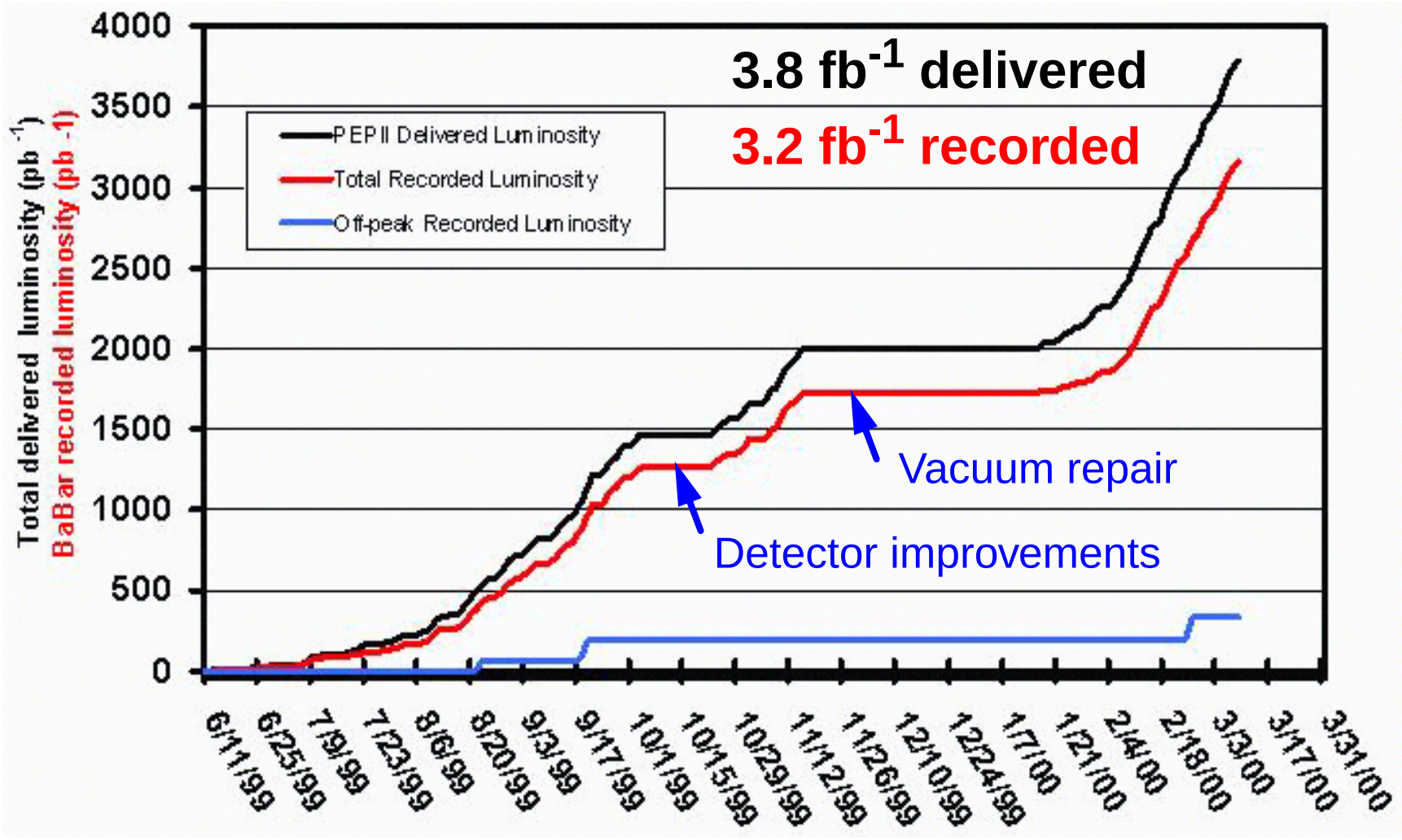
First collision May 26, 1999

	Design	Achieved
Luminosity ($cm^{-2}s^{-1}$)	3×10^{33}	1.7×10^{33}
No. of bunches	1658	829
LER current (mA)	2140	960
HER current (mA)	610	750



>1/2 design luminosity achieved

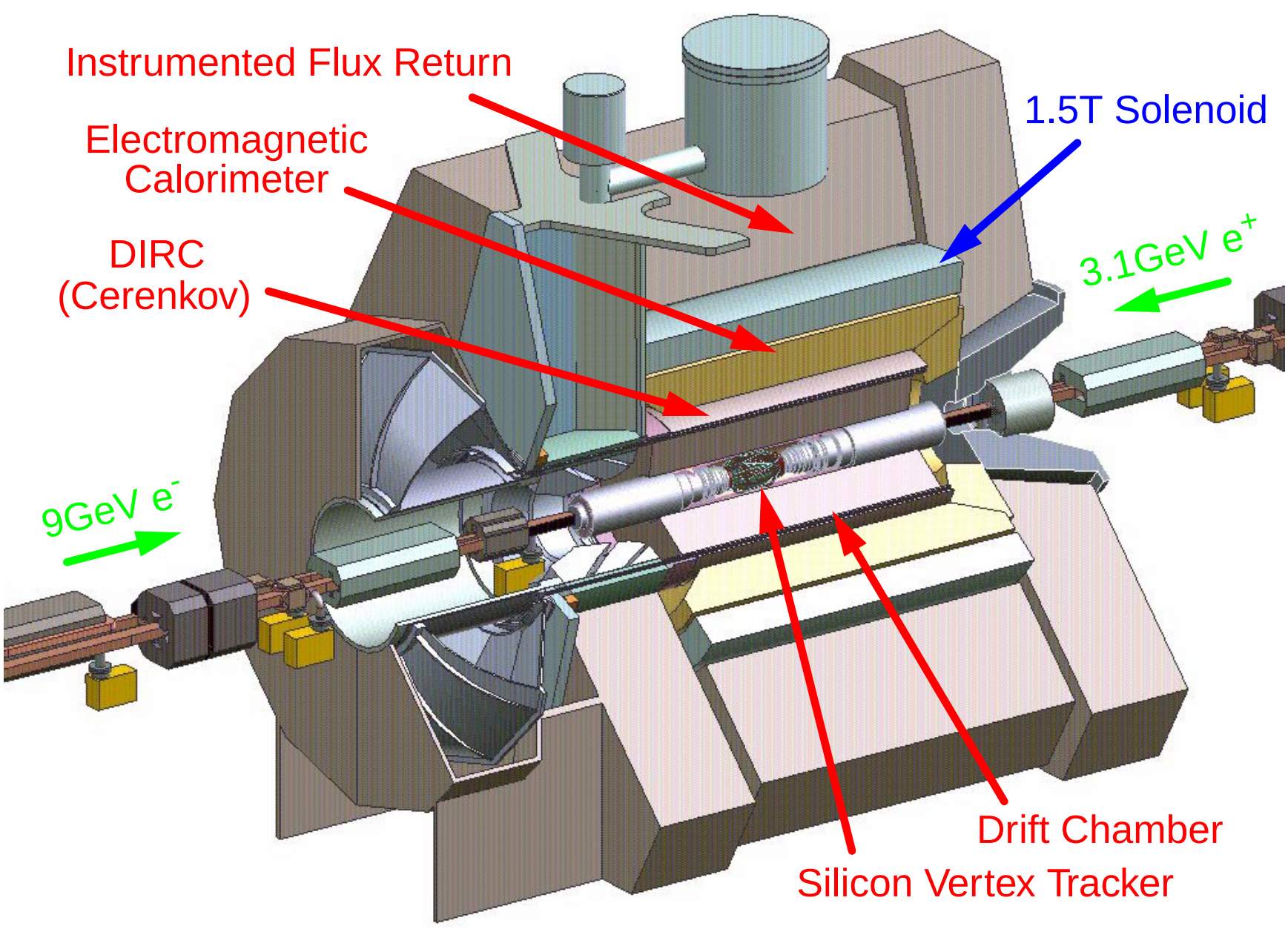
PEP-II Integrated Luminosity



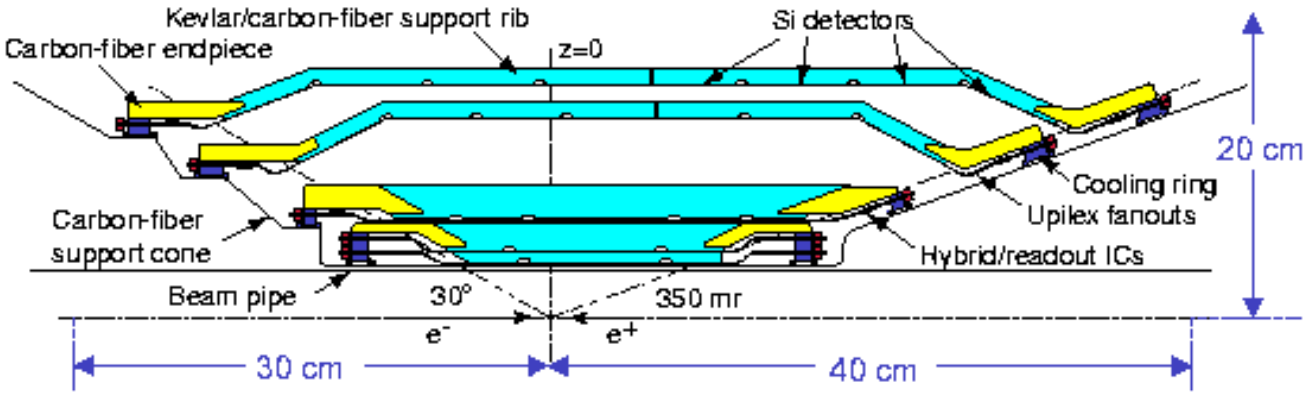
Current run continues through August 2000

→ accumulate **10 fb^{-1}** on-peak

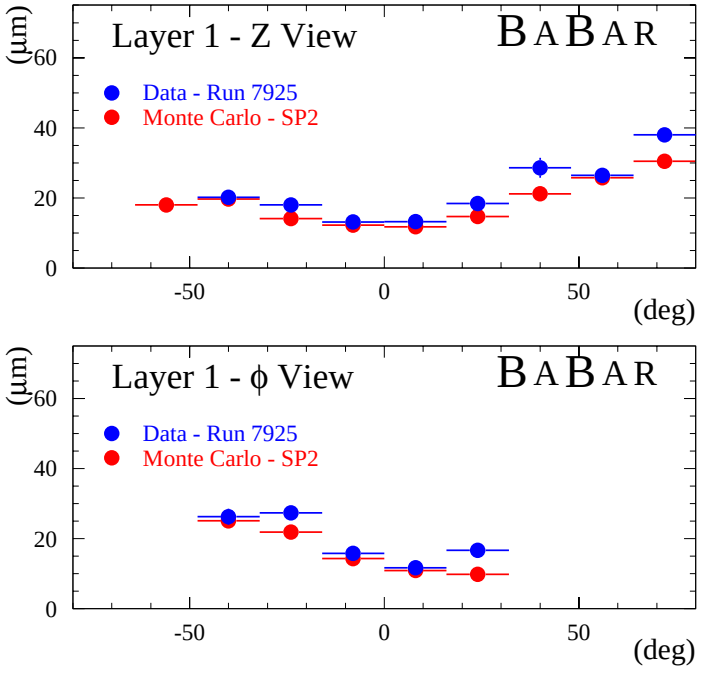
BABAR Detector



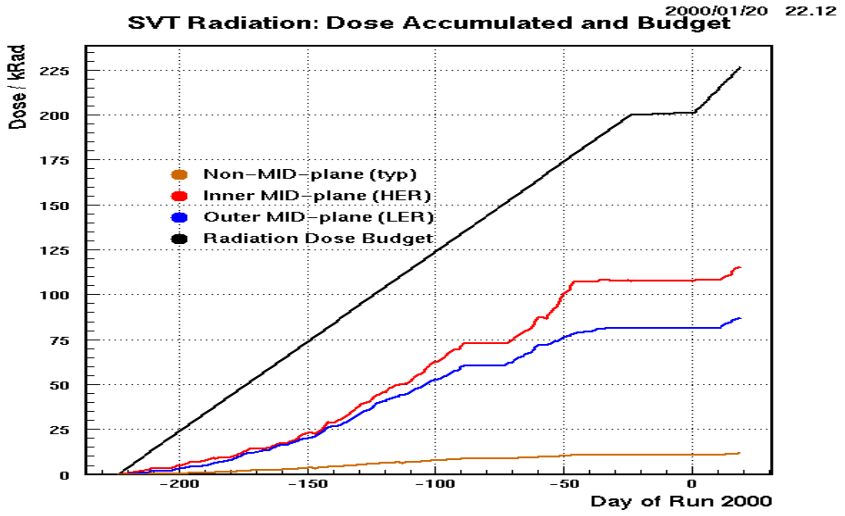
Silicon Vertex Tracker (SVT)



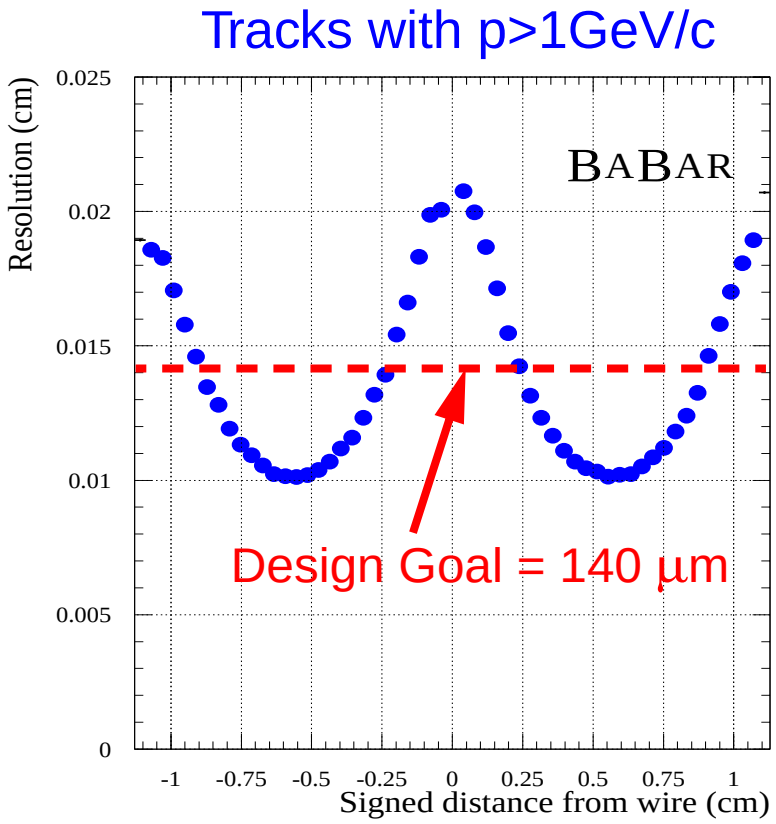
SVT Hit Resolution vs. Incident Track Angle



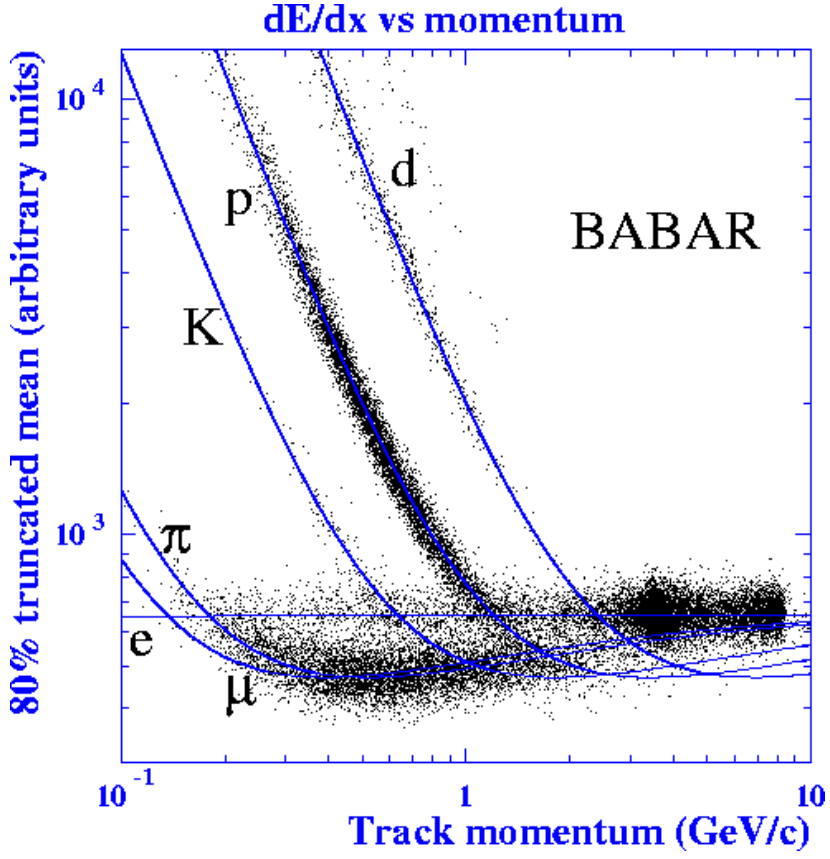
- 5 layer double-sided Si detector
- Hit resolution in data (●) reached design: ~15 μm at 0°
- Radiation hard up to 2 Mrad



Drift Chamber (DCH)

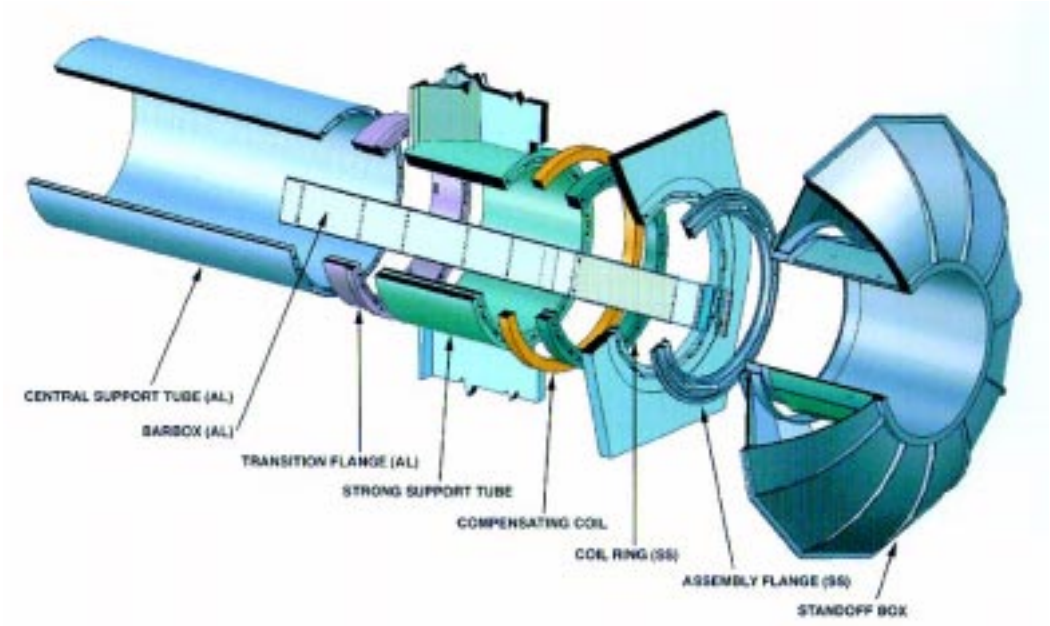


- He-iC_4H_{10} (80/20) for low multiple scattering
- Single hit resolution in data (●) reached design: <140 μm



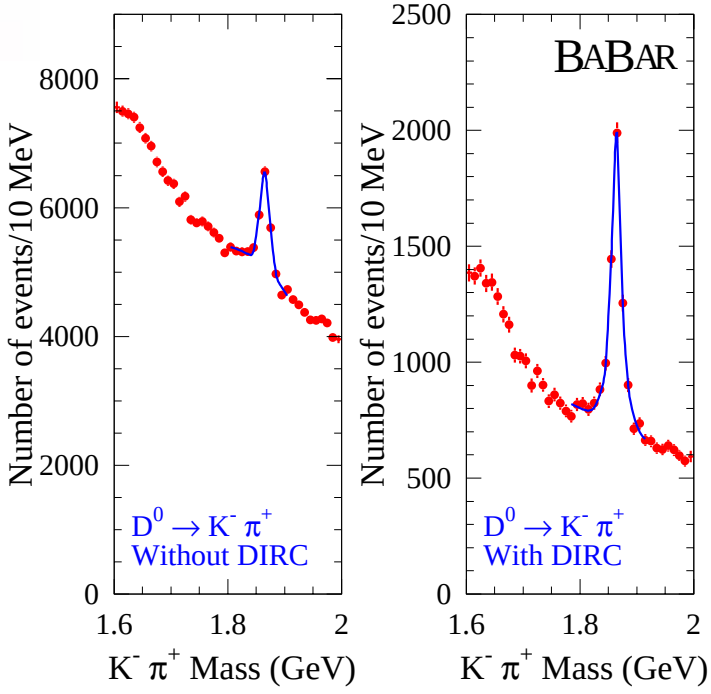
- dE/dx resolution ~7.5% for Bhabhas (design 7%)
- K/π separation >2σ up to 700 MeV/c → DIRC covers p > 500 MeV/c

DIRC: the PID Device



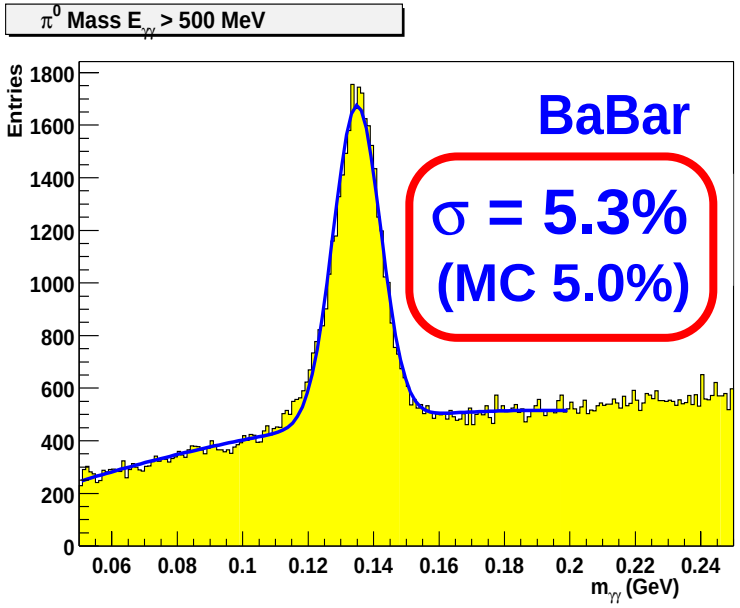
- Cerenkov light in quartz
  → transmitted by internal reflection
  → detected by PMTs
- 3 mrad resolution achieved (target 2 mrad)
- K/π separation at 4 GeV/c is 6.5 mrad

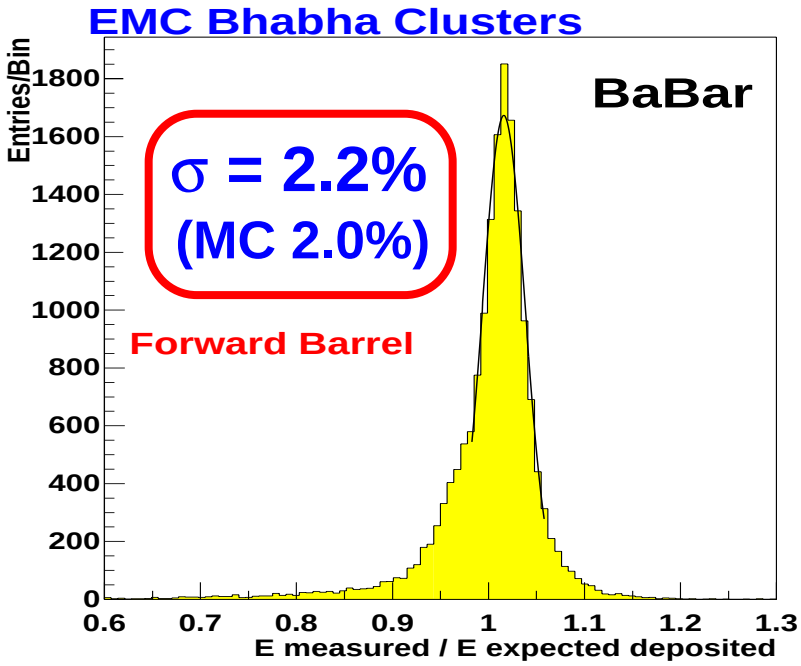
- K efficiency ~80% for $D^0 \to K^+\pi^-$ inside the acceptance
- Background rejection factor ~5 (NB: background contains kaons)



Electromagnetic Calorimeter (EMC)

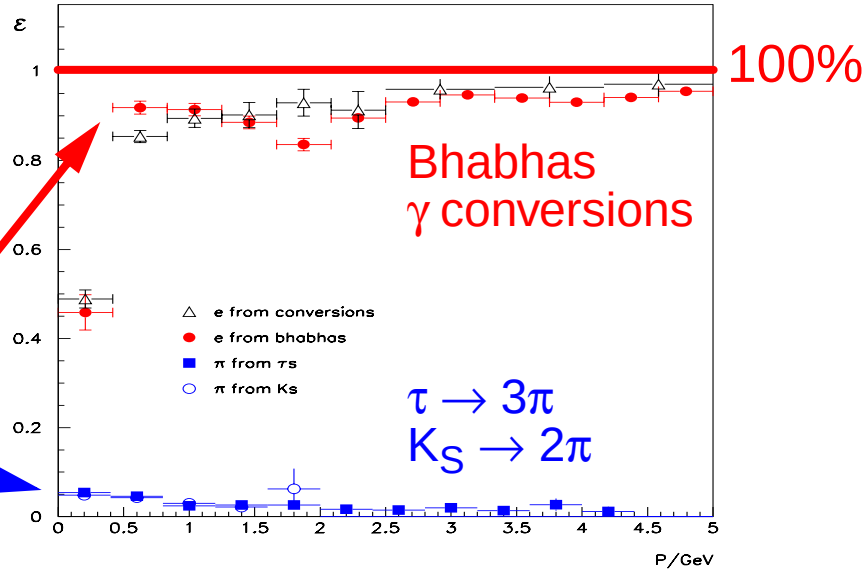
- CsI(Tl) with photodiode readout
- E(Bhabha) and m(π^0) resolutions close to Monte Carlo





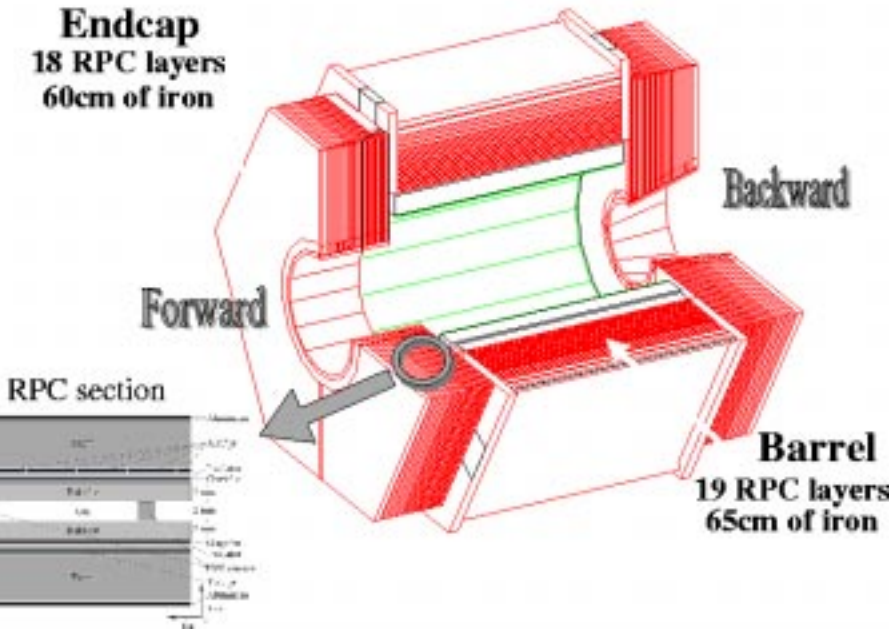
Electron ID (p > 0.5 GeV)

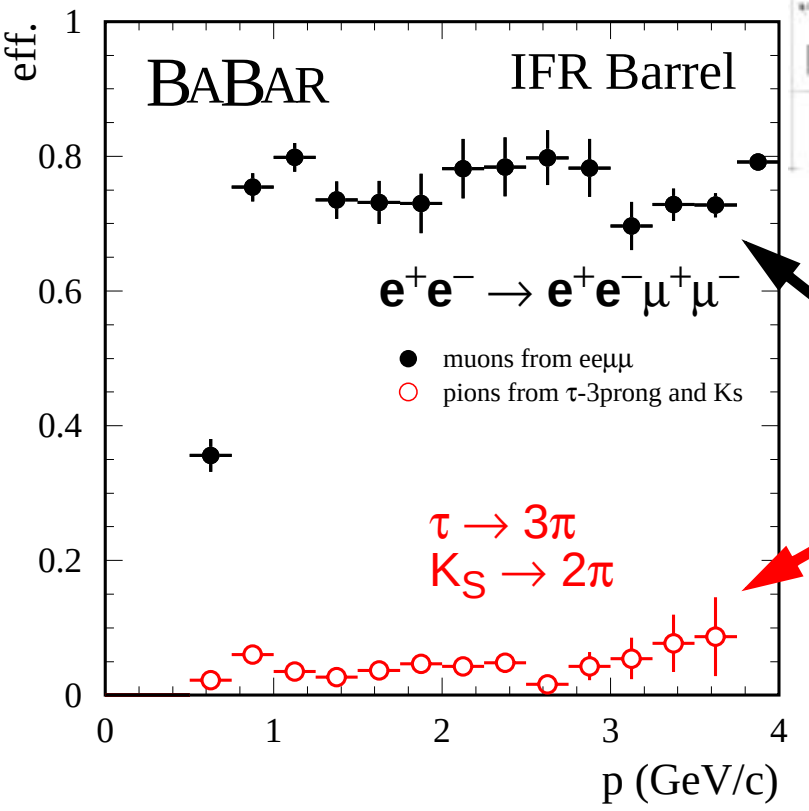
Electrons	>90%
Pions	1–2%



Instrumented Flux Return (IFR)

- Bakelite-based RPCs sandwiched between iron plates
- Muons above p = 0.5 GeV/c identified
- Neutral hadrons (K_L) detected





Muon ID (p > 0.5 GeV)

Muons	>75%
Pions	~3%

Are We Ready to Measure sin2β?

PEP-II had a terrific startup!

- Collected 3.2 fb^{-1} on tape → But we need more

BABAR works beautifully

- Initial problems have been solved
- Performance very promising → Still much to do (calibration!)

Physics analysis has started

- Signals are seen in key channels → Limited statistics

→ We don't have a CP measurement just yet

What can I show you today?

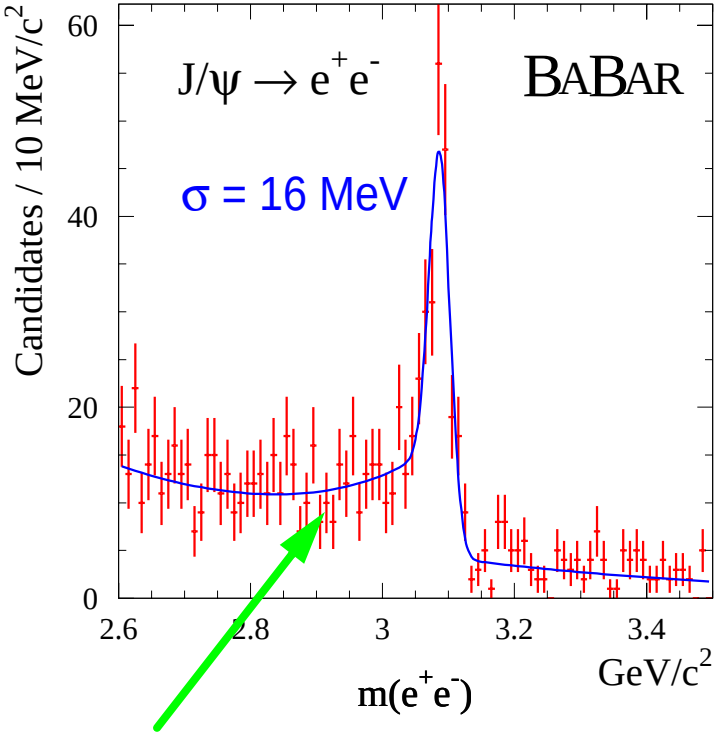
Examples of what we have done to demonstrate

- ➤How well we understand the detector
- ➤How well the data agree with our expectation
- ➤How realistic is our plan to measure sin2β by Summer

Everything is PRELIMINARY and improving as I speak

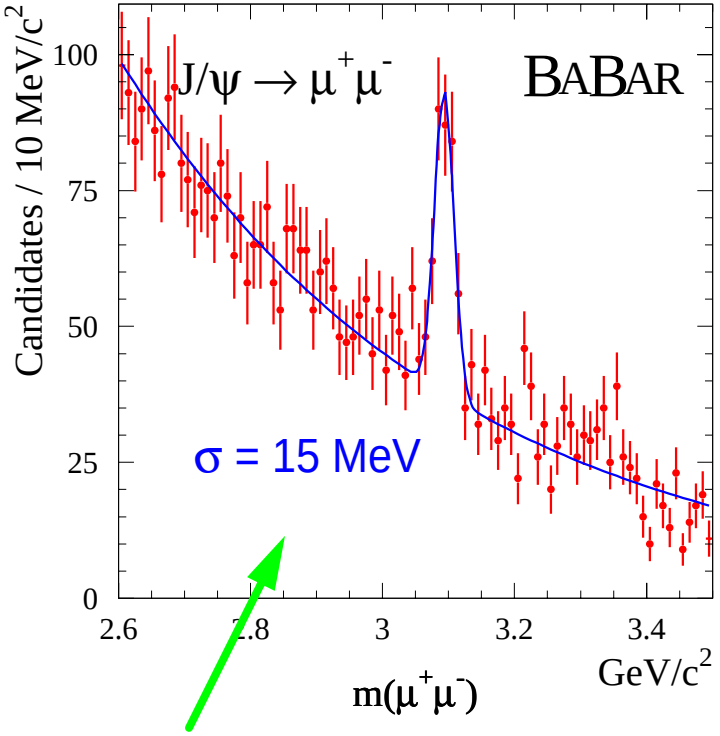
$J/\psi \to l^+l^-$ Signal

$J/\psi \to e^+e^-$ (~540 pb^{-1})



Tail due to Bremsstrahlung

$J/\psi \to \mu^+\mu^-$ (~380 pb^{-1})

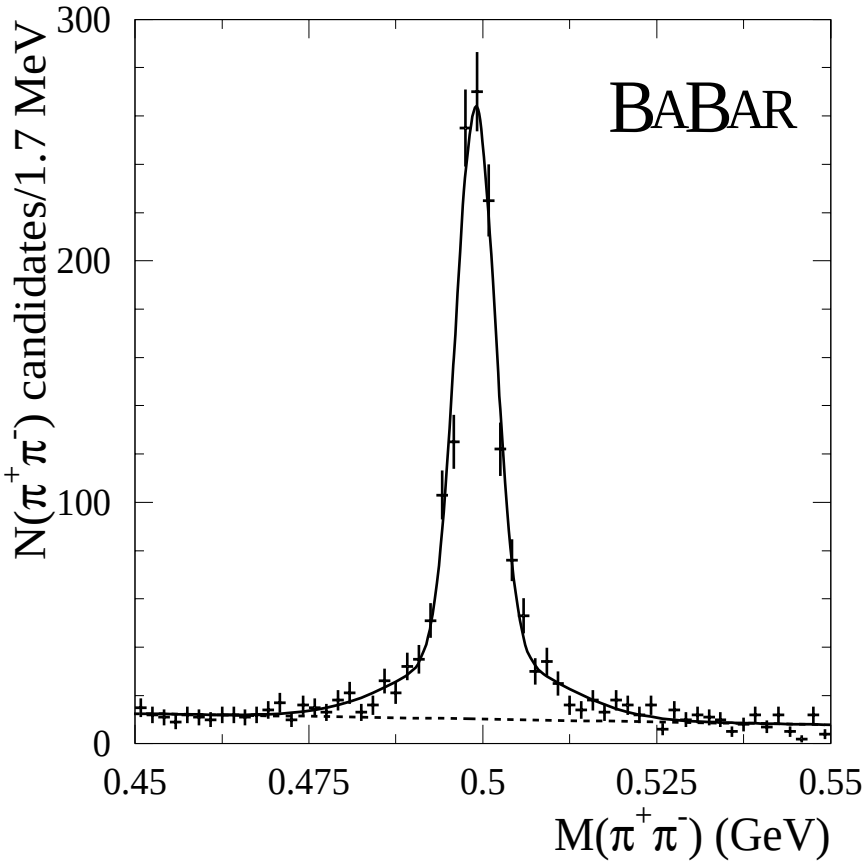


Background due to muon ID

- Efficiency consistent with expectation

→ Already reasonable, but can be improved

$K_S \to \pi^+\pi^-$ Signal

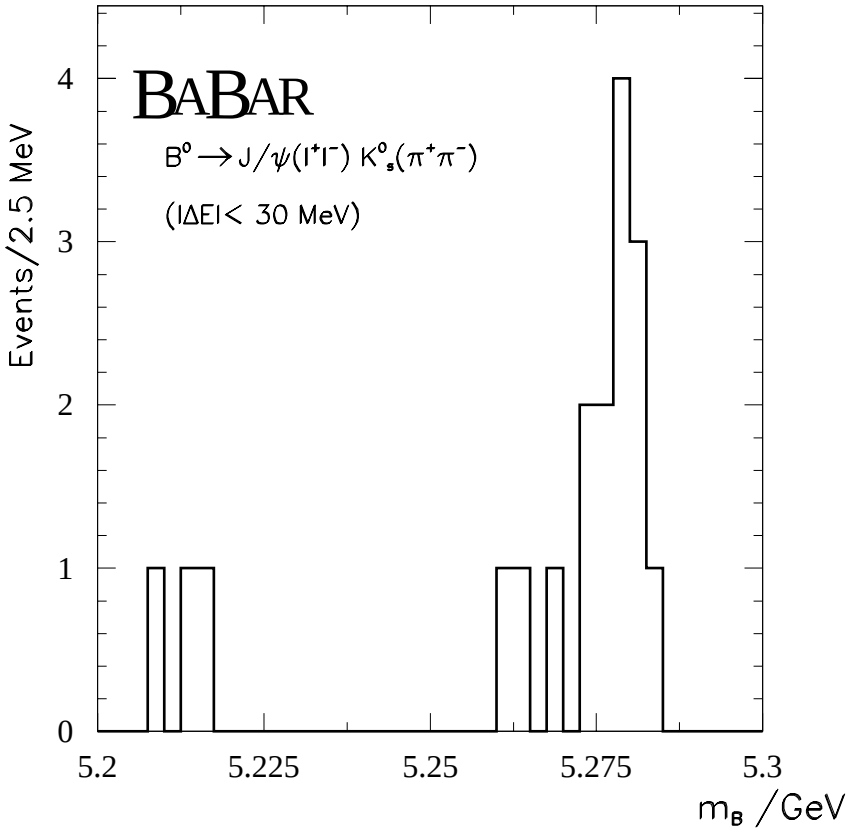


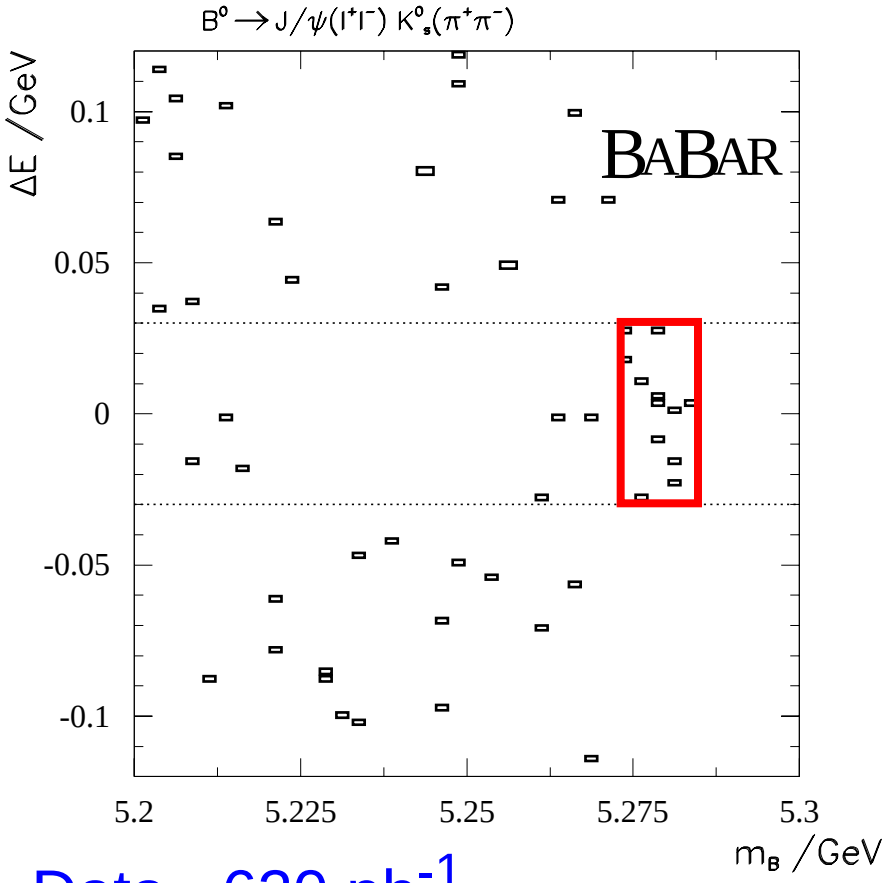
- Mass resolution OK

Mass	498.94 ± 0.12 MeV
σ_{narrow}	2.8 MeV (69%)
σ_{wide}	11 MeV (31%)

$B^0 \to J/\psi\, K_S$ Signal

- $\Delta E = E_B^{CMS} - E_{beam}^{CMS}$
- $m_B = \sqrt{(E_{beam}^{CMS})^2 - (p_B^{CMS})^2}$





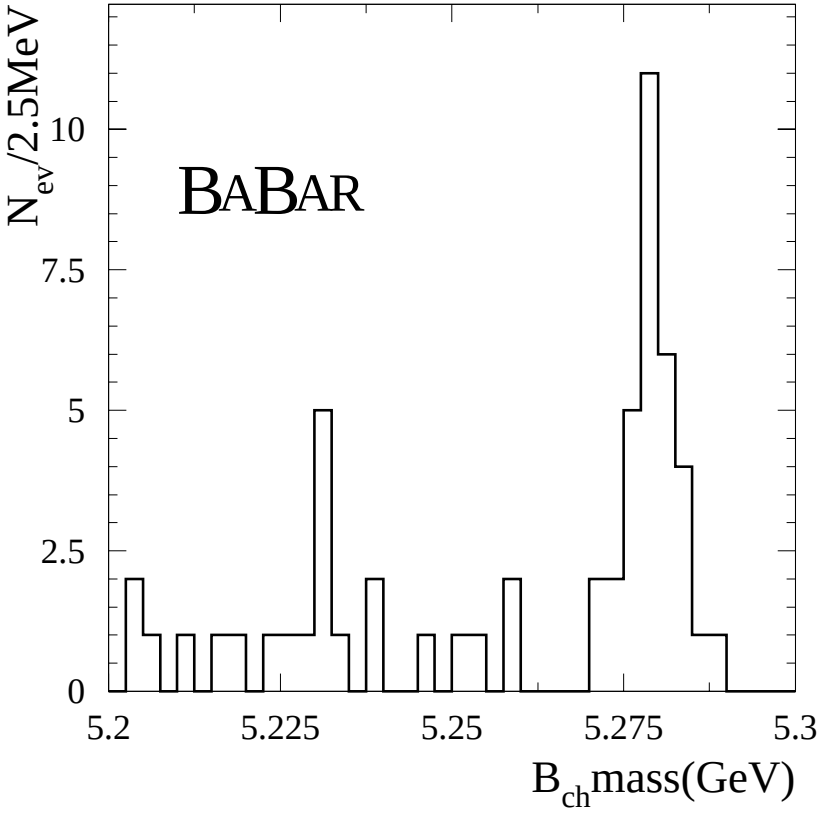
Data ~620 pb^{-1}

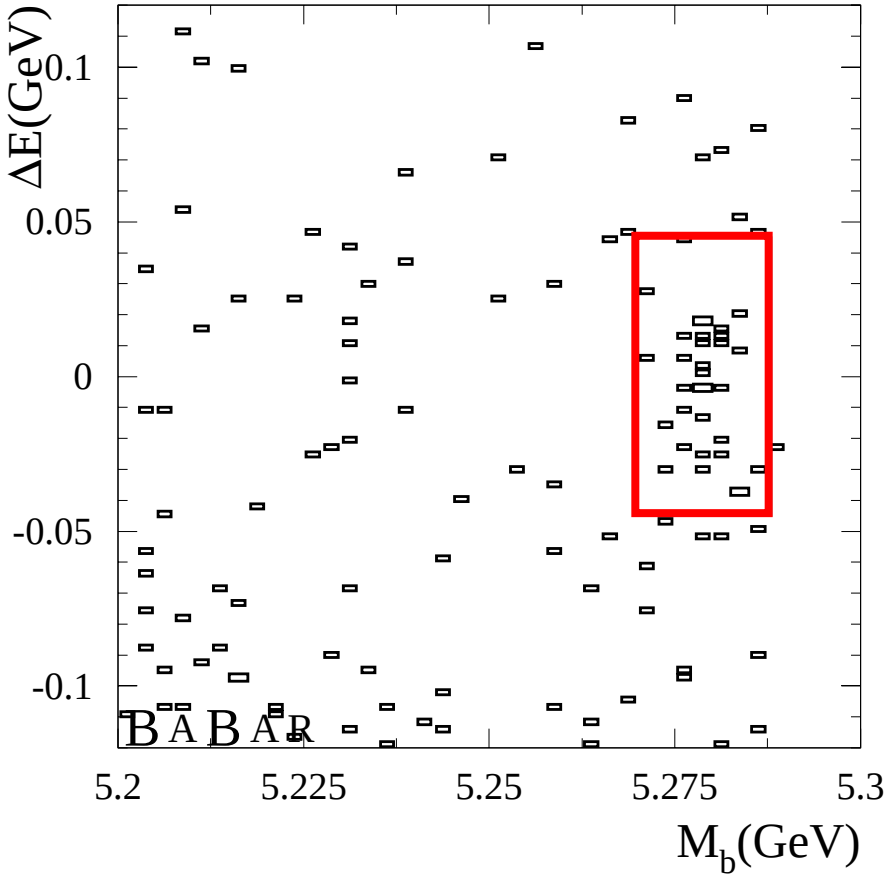
Signal	12 events
Background	1.4 ± 0.2
Expected signal	9.8 ± 1.1

$B^+ \to J/\psi\, K^+$ Signal

Data ~620 pb^{-1}

Signal	41 events
Background	5.0 ± 0.6
Expected signal	39.0 ± 3.4

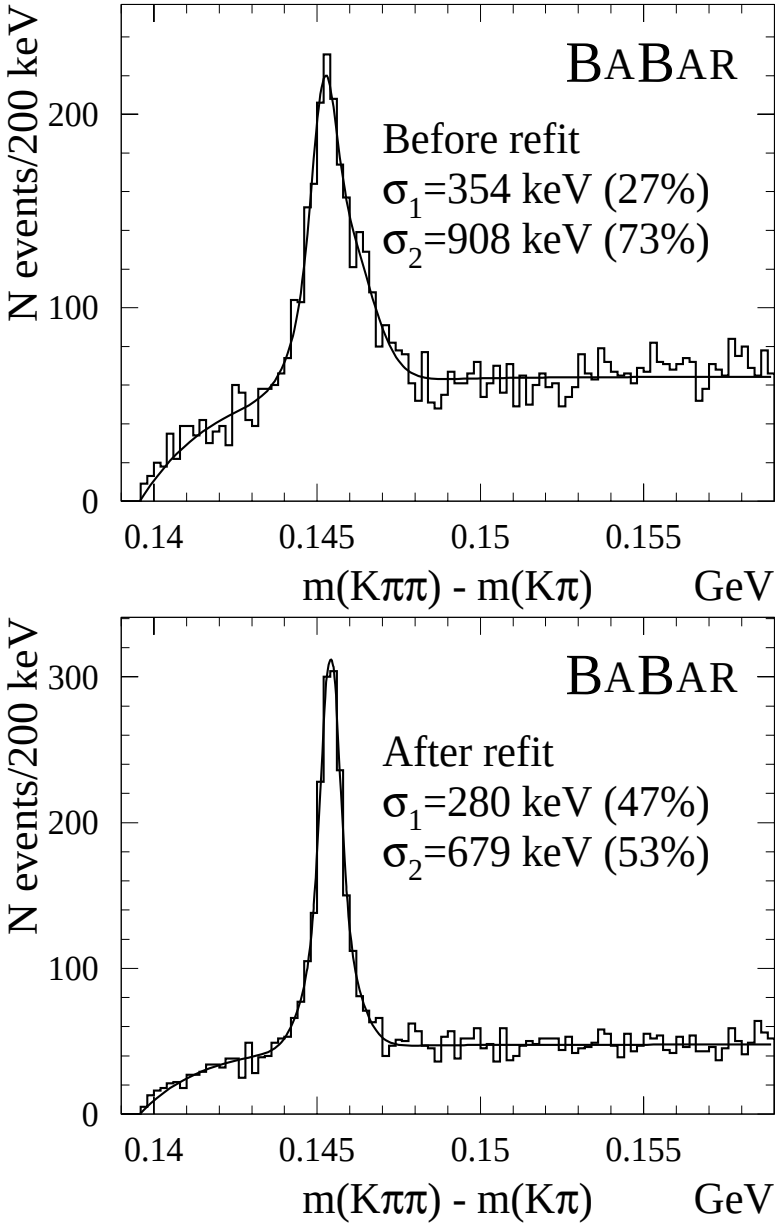




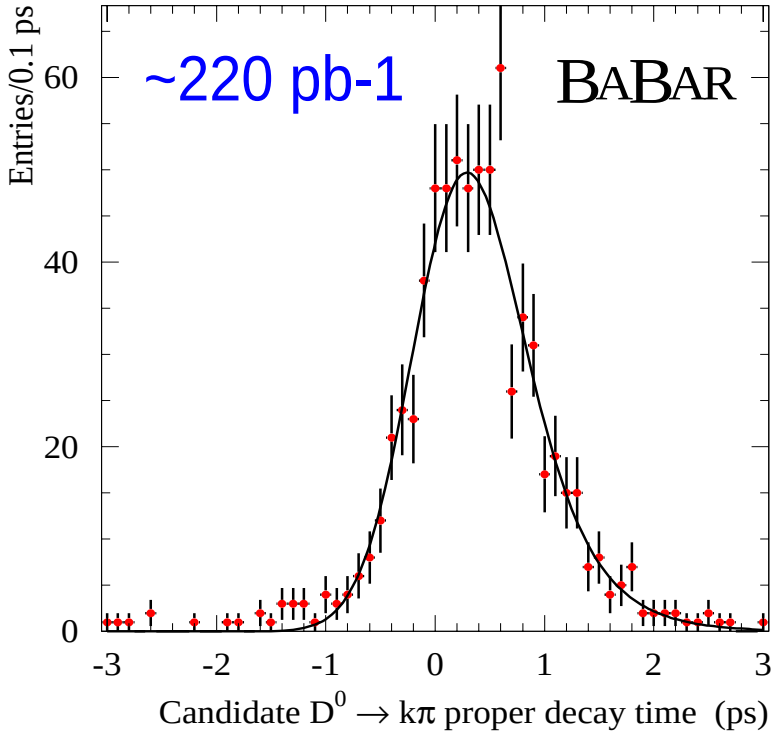
→ J/ψ K signals under control

- Yields agree with expectations
- Resolution OK
- Bkg will improve (calibration, PID)

D* Signal and Vertexing

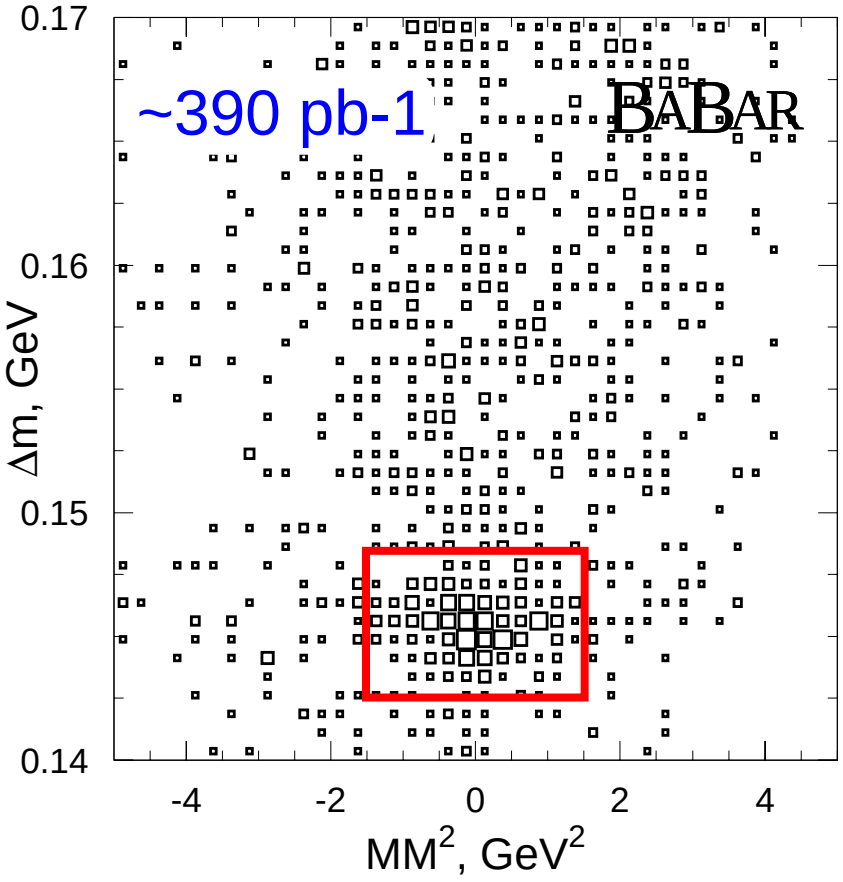


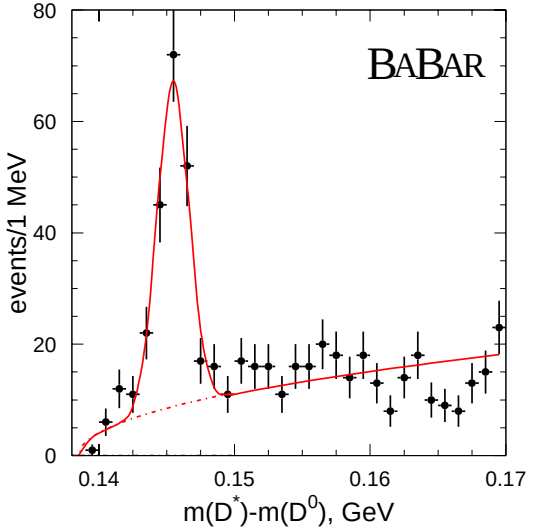
- Δm resolution improves with beam profile constraint

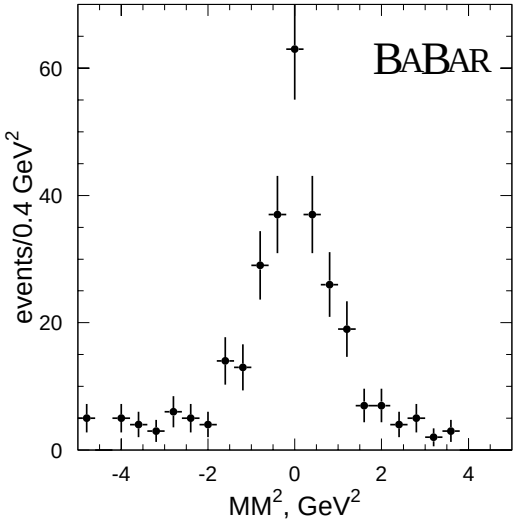


- Simple exponential ⊗ gaussian fit
- Resolution as expected
- Lifetime consistent with PDG

$B^0 \to D^{*-} e^+ \nu$ Signal







- $\Delta m = m(D^{*-}) - m(D^0)$, MM = missing mass
- ~120 signal events

→ Will be used for a mixing measurement

→ Tagging efficiency and purity → CP measurement

Summary and Outlook

PEP-II had a terrific first year

- Record luminosity: 1.7 x 10^{33} $cm^{-2}s^{-1}$. 80 pb^{-1}/day
- BABAR recorded 3.2 fb^{-1} $\rightarrow$ 10 fb^{-1} by the end of August

BABAR is working great

- Performance approaching the design goals

Analyses are progressing rapidly

- Signals seen in key channels. Efficiency & resolution OK
- Vertexing resolution OK. More tests will follow
- Tagging being studied using real data, e.g. $B^0 \rightarrow D^*/\nu$

$\rightarrow$ All ingredients for the CP measurement getting ready

More data is coming!!!

- With 10 fb^{-1}: **Expect ~160 J/ψ K_S events $\rightarrow$ $\sigma(\sin 2\beta) \leq 0.3$**