Precision measurement of BF($B^0 \to D^{*-}\pi^+\pi^-\pi^+$) at *BABAR*

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Representing the *BABAR* Collaboration

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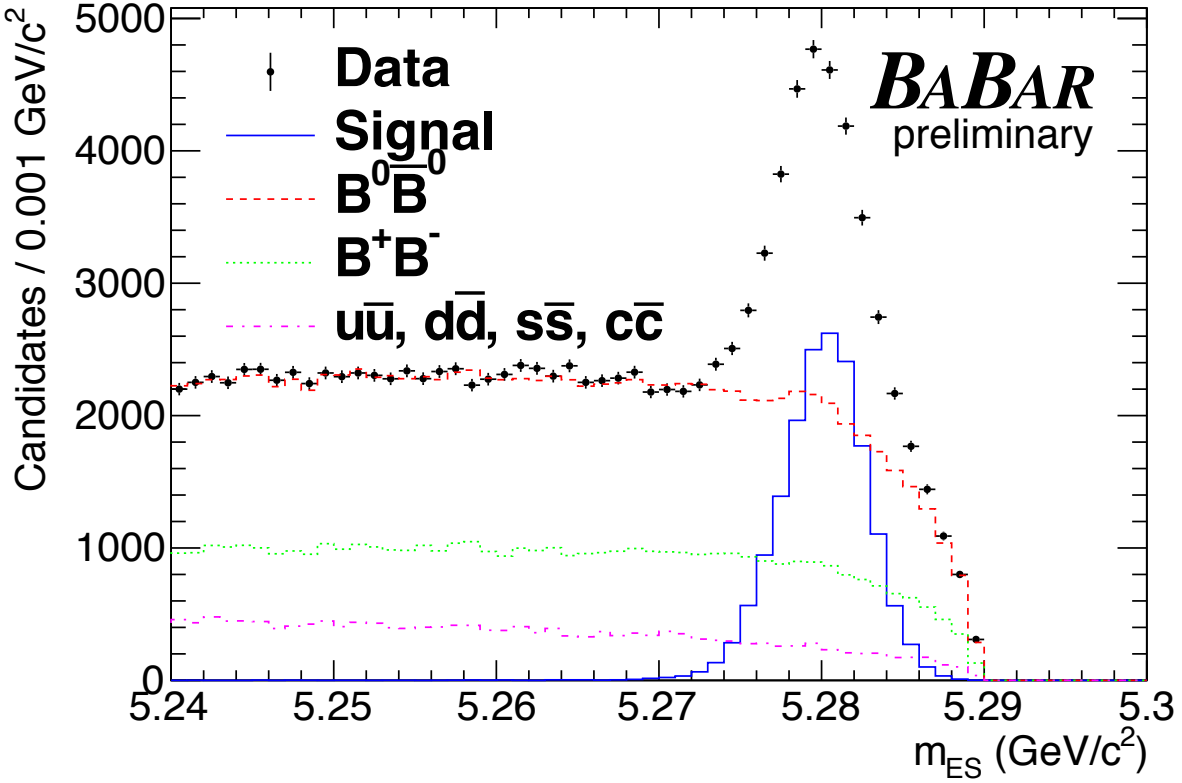
Motivation

- BABAR, Belle, and LHCb observed excesses of $B \to D^{(*)}\tau\nu$ relative to $B \to D^{(*)}\mu\nu$ and $B \to D^{(*)}e\nu$
- The HFAG delivered an average value yielding a 3.9σ deviation from the standard model prediction (D and D^*)
- A measurement of the branching fraction $BF(B \to D^*\tau\nu)$ using $\tau \to 3\pi\nu$ at a hadronic collider normalized to $BF(B \to D^*3\pi)$ may yield the observation of a further deviation from the SM
- This possibility relies on a precise measurement of $BF(B \to D^*3\pi)$, which has a current world average value of $(7.0 \pm 0.8) \times 10^{-3}$
- A clean environment in which to study the mass of the 3π system and a_1^+ properties
- The use of charge conjugate reactions is implied

Experimental Technique

- We use a sample of 470.9 x 10^6 pairs of B mesons
- Fully reconstruct the decay $B^0 \to D^{*-}\pi^+\pi^-\pi^+$, where $D^{*-} \to \overline{D}^0\pi^-, \overline{D}^0 \to K^+\pi^-$
- We apply loose kinematic selection criteria
- Use MC-simulated events to study backgrounds and signal reconstruction efficiencies

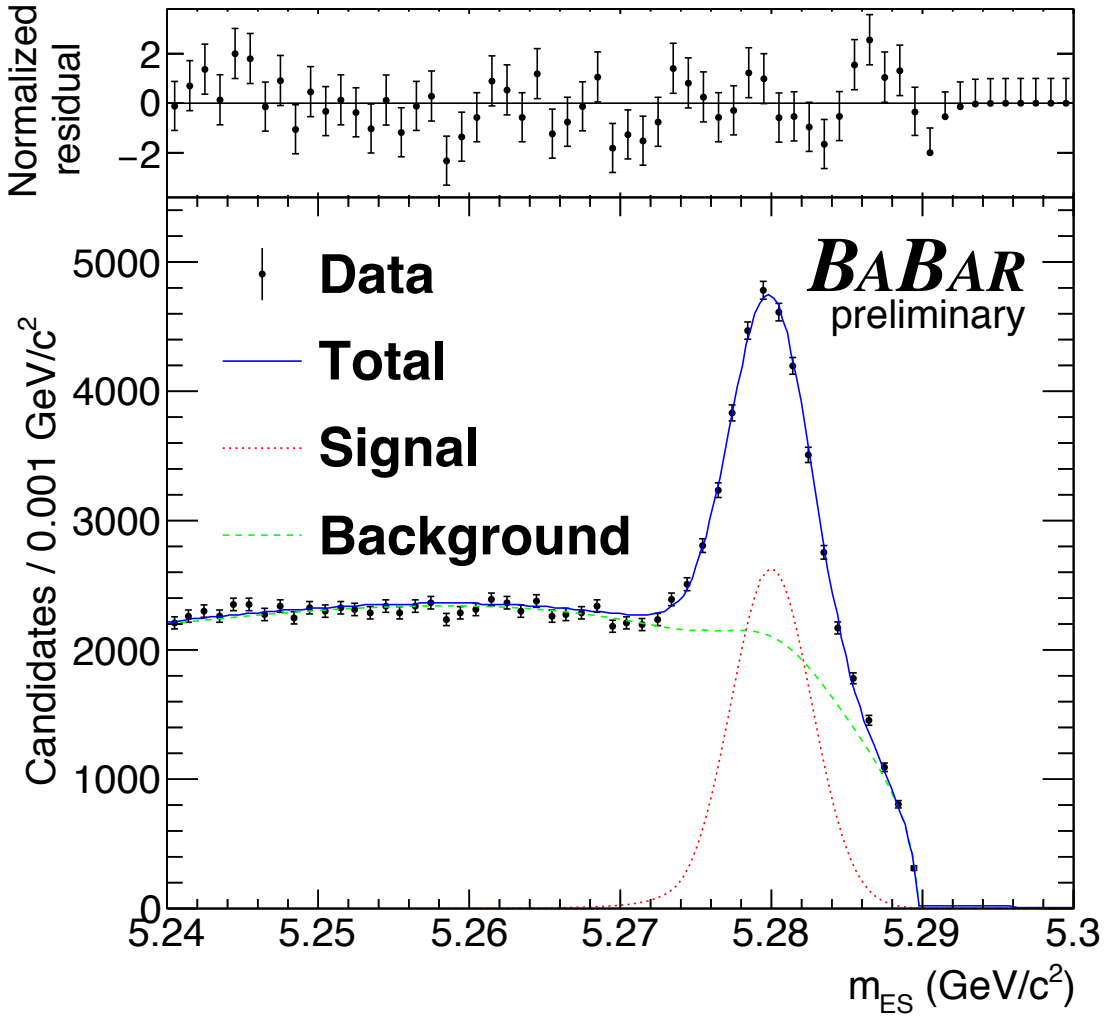
$$m_{ES} = \sqrt{s/4 - p_B^2}$$



Background histograms are stacked
Signal histogram is from MC

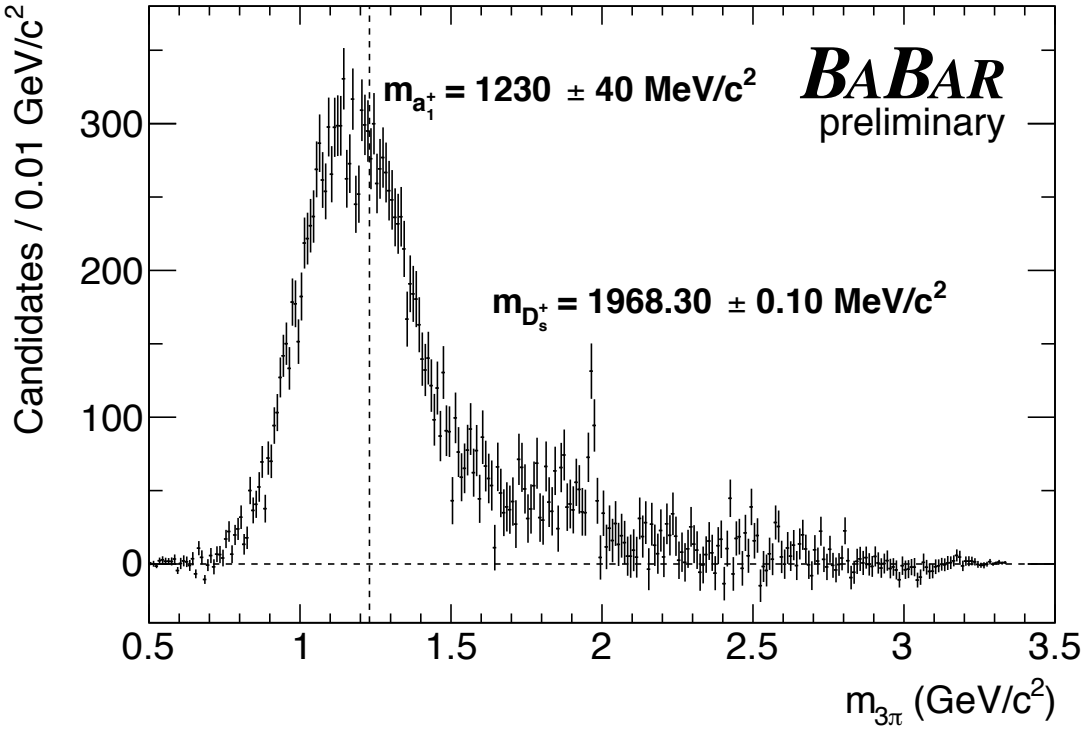
Signal Extraction

- Use an Argus function to model non-peaking backgrounds
- Use Gaussian functions predicted by MC as models of peaking backgrounds
- Use a Crystal Ball function for the signal component
- Perform an unbinned extended-maximum-likelihood fit for the number of signal candidates (17767±324)



3π mass spectrum study

- Perform sideband subtraction of m_{ES} to obtain the 3π invariant mass spectrum of the signal
- The dominant contribution comes from $D^{*-}a_1^+$; we note that our signal peaks at ~1.15GeV/c^2, which is lower than the PDG value; there also is activity in the region 1.7-1.9GeV/c^2, which may be due to the $J^P = 0^- \pi(1800)$
- A $D^{*-}D_s^+$ peak is also apparent
- Perform efficiency corrections as a function of 3π mass



Final Result

We obtain the following preliminary value

BF($B^0 \to D^{*-}\pi^+\pi^-\pi^+$) = (7.26 ± 0.11 ± 0.31) x 10^{-3}

(singly-charmed B decays only)

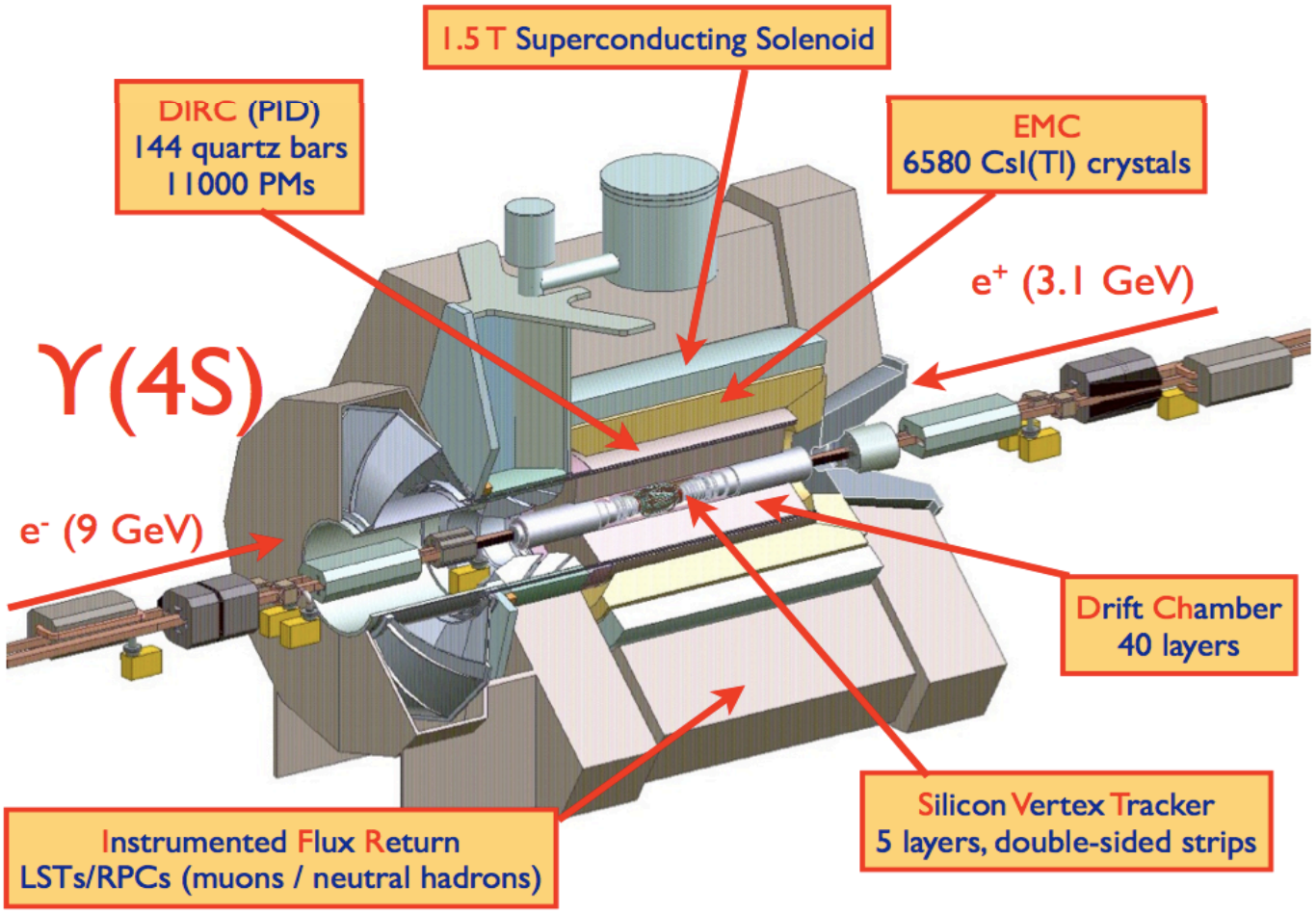
BF($B^0 \to D^{*-}\pi^+\pi^-\pi^+$) = (7.37 ± 0.11 ± 0.31) x 10^{-3}

(includes contamination from doubly-charmed B decays)

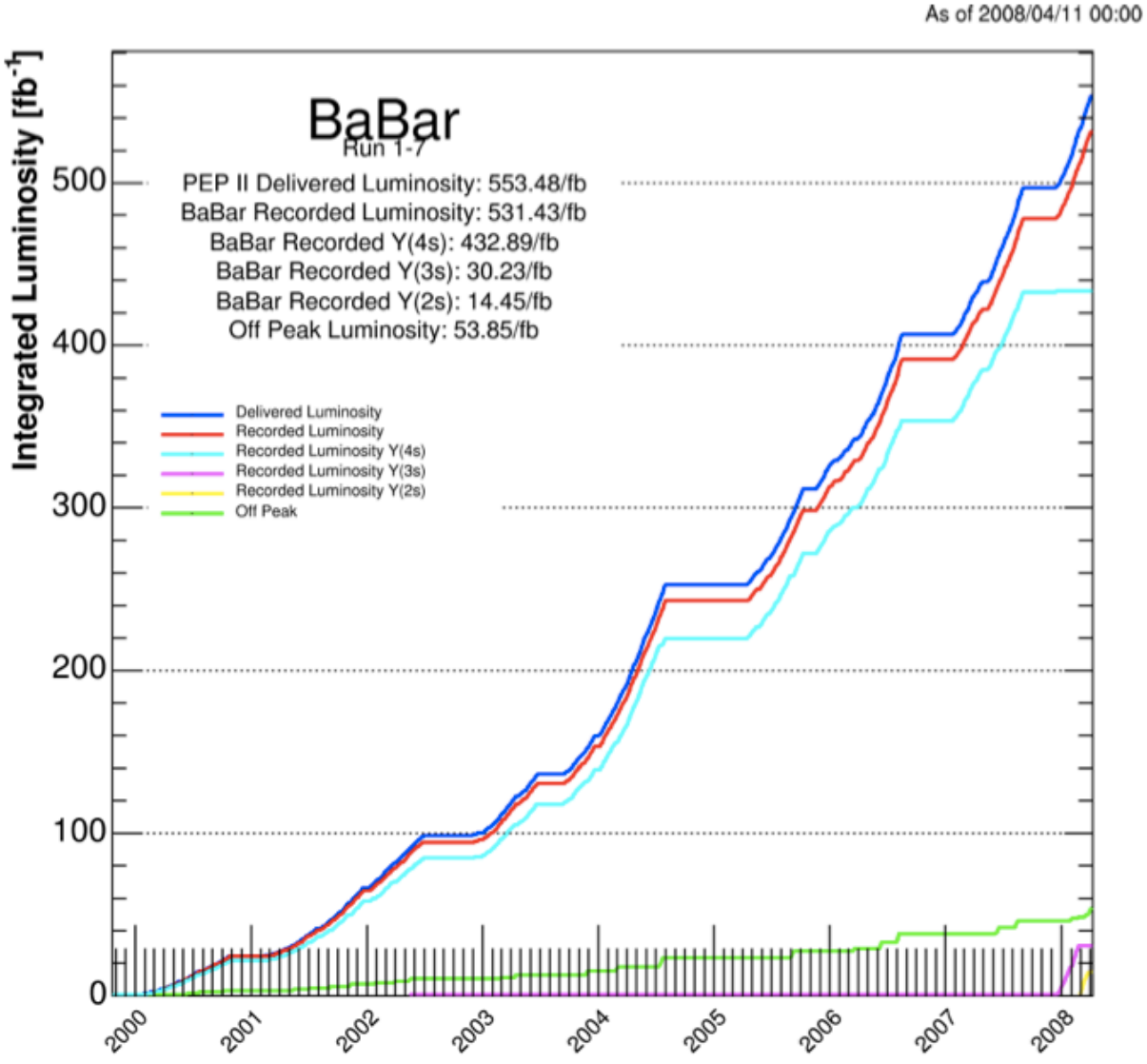
Source	Uncertainty
Fit algorithm and peaking background	2.4%
Track-finding	2.0%
$\pi^+\pi^-\pi^+$ invariant-mass modeling	1.7%
D^* and D^0 decay branching fractions	1.3%
$\Upsilon(4S) \to B^0\overline{B}^0$ decay branching fraction	1.2%
K^+ identification	1.1%
MC statistics	0.9%
$B\overline{B}$ counting	0.6%
Total	4.3%

Extra Slides

The BABAR detector



BABAR data sample



Selection criteria

- The centre-of-mass frame energy of the B^0 candidate is within 90 MeV of half the beam energy
- The reconstructed mass of the D^0 candidate is within 20 MeV/c^2 of the nominal value
- The reconstructed mass difference between the D* and D^0 candidates lie in the range 0.1435 to 0.1475 GeV/c^2
- A multilayer perceptron that selects B^0 candidates based of decay shape geometry that rejects 69% of backgrounds and keeps 80% of B^0 mesons
- One of the daughters of the D^0 candidate is identified as a charged kaon

References

- BABAR paper: $\bar{B} \to D^{(*)}\tau^-\bar{\nu}_\tau$
  - Phys. Rev. D **88,** 072012 (2013)
- Belle paper: $\bar{B} \to D^{(*)}\tau^-\bar{\nu}_\tau / \bar{B} \to D^{(*)}\ell^-\bar{\nu}_\ell$
  - Phys. Rev. D **92,** 072014 (2015)
- LHCb paper: $\bar{B} \to D^{(*)}\tau^-\bar{\nu}_\tau / \bar{B} \to D^{(*)}\mu^-\bar{\nu}_\mu$
  - Phys. Rev. Lett. **115,** 111803 (2015)
- HFAG result
  - http://www.slac.stanford.edu/xorg/hfag/semi/eps15/eps15_dtaunu.html