Recent B physics results from BABAR and BELLE

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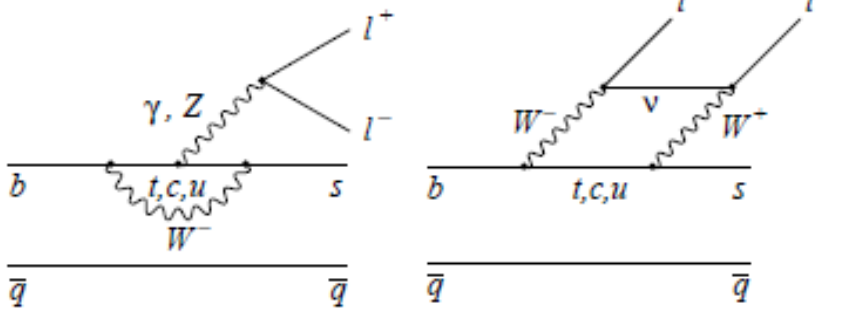
B physics : active search for new physics

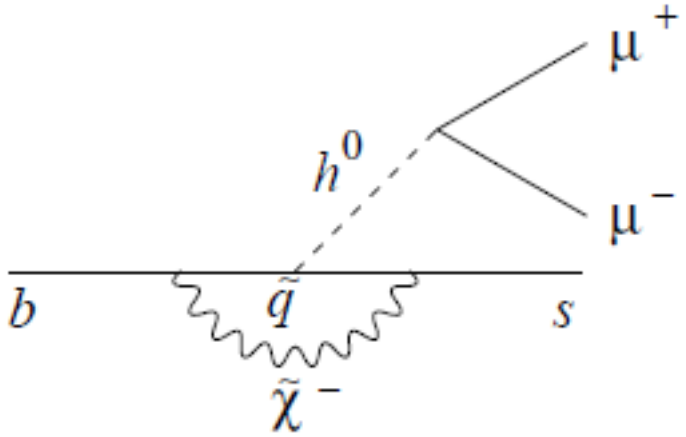
- Several years after the closure of the B factories, and before the start in a few years of BELLE-II, BABAR and BELLE are still actively searching for hints of deviations from SM predictions, in complement with LHCb data, now occupying the front seat.
- No deviations was found where one was expecting potential large effects (CP violation sector, $B_s \to \mu\mu$, $B \to \tau\nu$)
- But some NP hints persist in two areas $B \to K^* ll$ and $B \to D^* \tau\nu$

Outline : Two hot topics in B decays

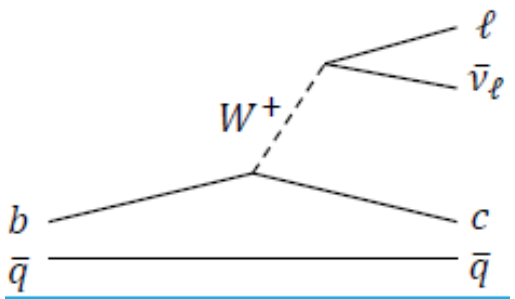
- B->K*l^+l^- : search for new physics in a b->s transition

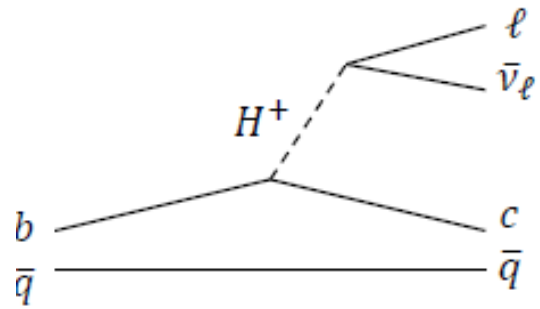
  Recent results from BABAR and BELLE





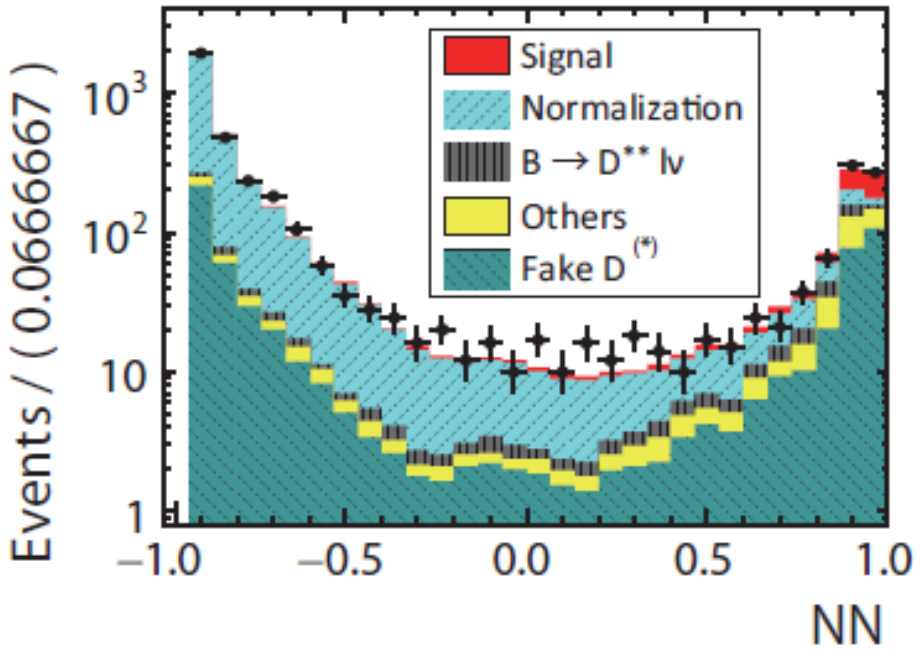
- B->D*$\tau\nu$: search for new physics in tree-level B decay
  - Recent results from BELLE
  - Precision measurement of BR(B^0->D*3π) from BABAR



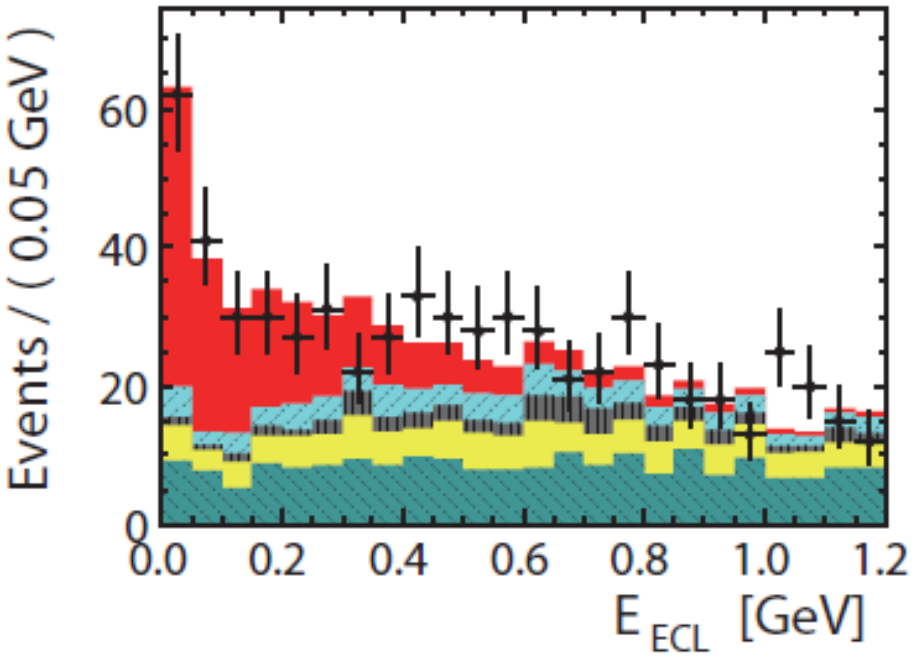


BELLE search for D*τν
New : semileptonic tag!! 771 fb^{-1}

arXiv 1603.06711



NN>0.8



N_{signal}=231 ± 23 (13.8 σ)

Energy left in the event besides the D* and the muon

BELLE Results and systematic uncertainties

TABLE I. List of relative systematic uncertainties in percent.

	$\mathcal{R}(D^*)$ [%]		
Sources	$\ell^{\rm sig} = e, \mu$	$\ell^{\rm sig} = e$	$\ell^{\rm sig} = \mu$
MC statistics for each PDF shape	2.2%	2.5%	3.9%
PDF shape of the normalization in $\cos\theta_{B\text{-}D^*\ell}$	$^{+1.1}_{-0.0}$%	$^{+2.1}_{-0.0}$%	$^{+2.8}_{-0.0}$%
PDF shape of $B \to D^{**}\ell\nu_\ell$	$^{+1.0}_{-1.7}$%	$^{+0.7}_{-1.3}$%	$^{+2.2}_{-3.3}$%
PDF shape and yields of fake $D^{(*)}$	1.4%	1.6%	1.6%
PDF shape and yields of $B \to X_c D^*$	1.1%	1.2%	1.1%
Reconstruction efficiency ratio $\varepsilon_{\rm norm}/\varepsilon_{\rm sig}$	1.2%	1.5%	1.9%
Modeling of semileptonic decay	0.2%	0.2%	0.3%
$\mathcal{B}(\tau^- \to \ell^- \bar{\nu}_\ell \nu_\tau)$	0.2%	0.2%	0.2%
Total systematic uncertainties	$^{+3.4}_{-3.5}$%	$^{+4.1}_{-3.7}$%	$^{+5.9}_{-5.8}$%

$$\mathcal{R}(D^*) = 0.302 \pm 0.030 \pm 0.011$$

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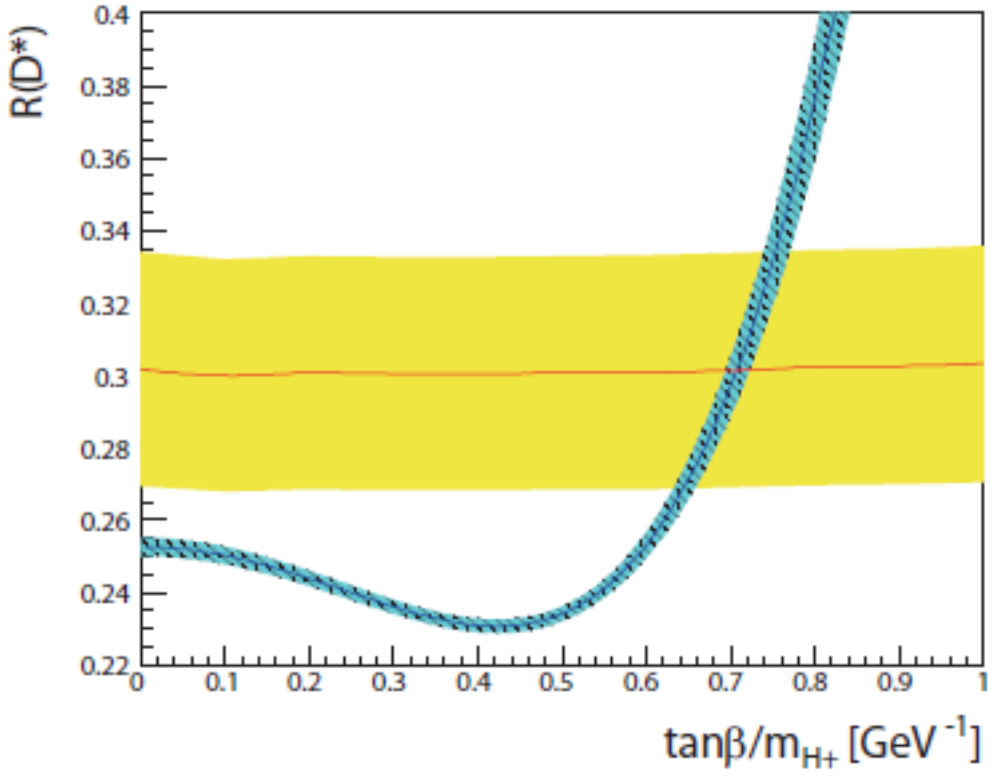
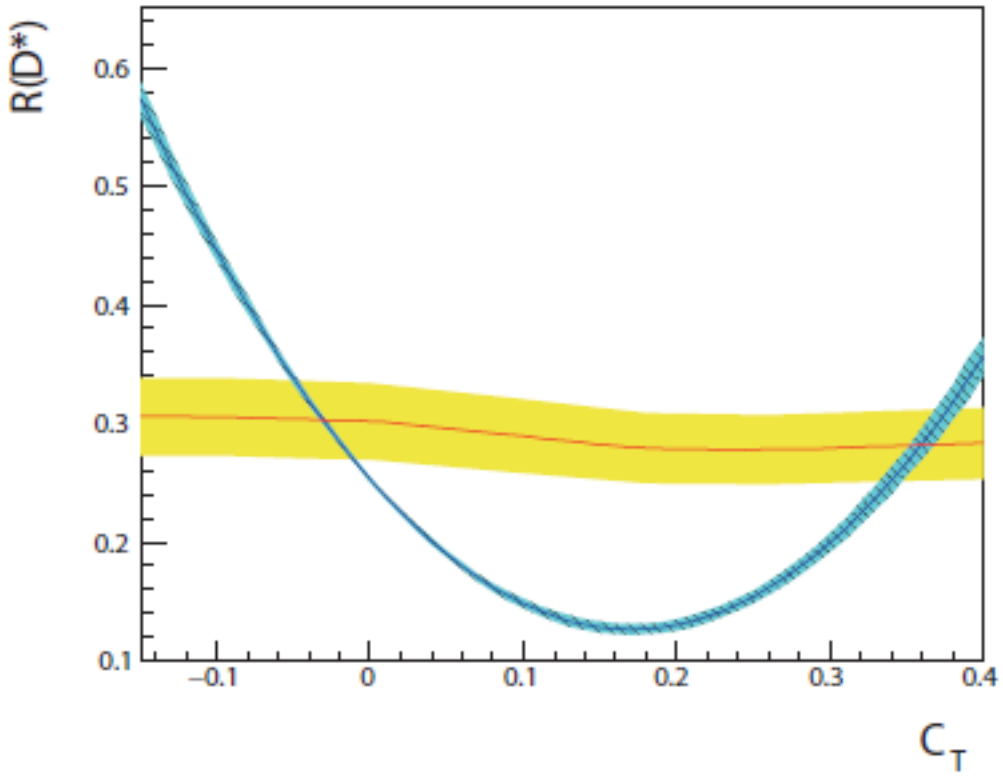
Interpretation for new physics : Higgs or leptoquark

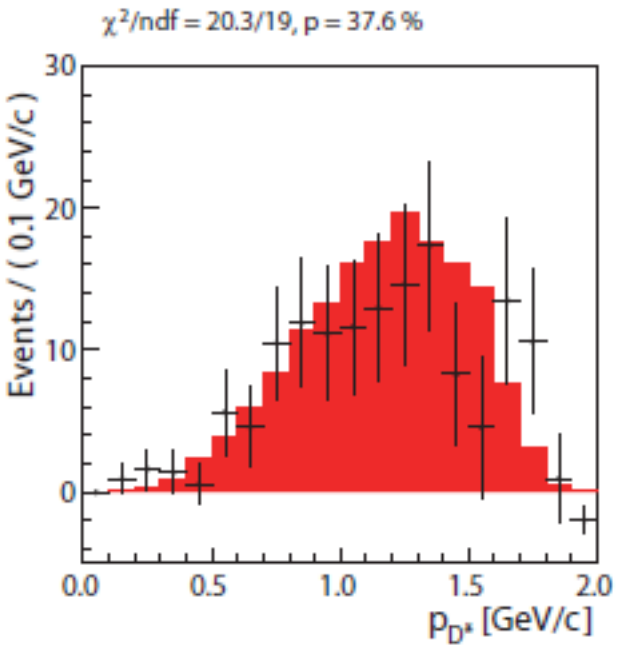


(a)Type II 2HDM.

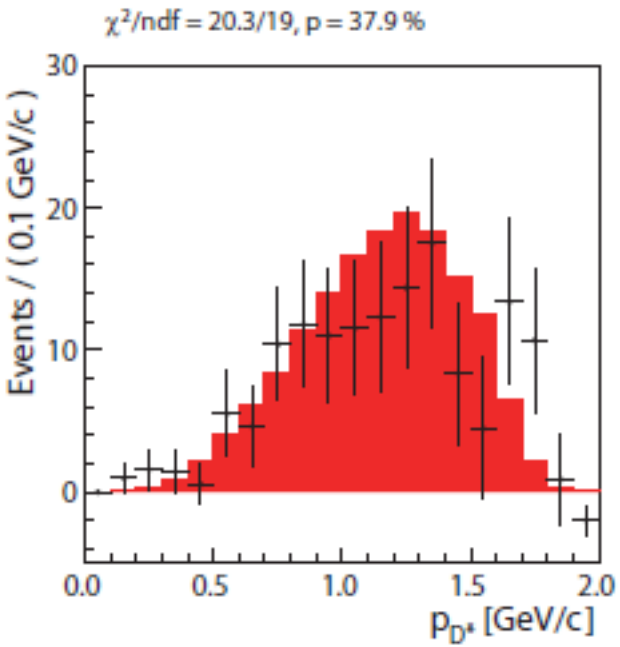


(b)R_2 type leptoquark model.

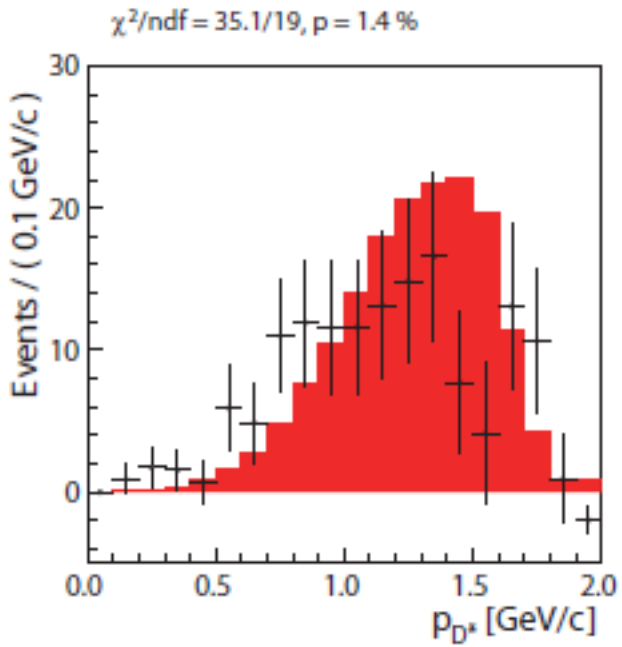
Distribution of the D* momentum



(a)SM.



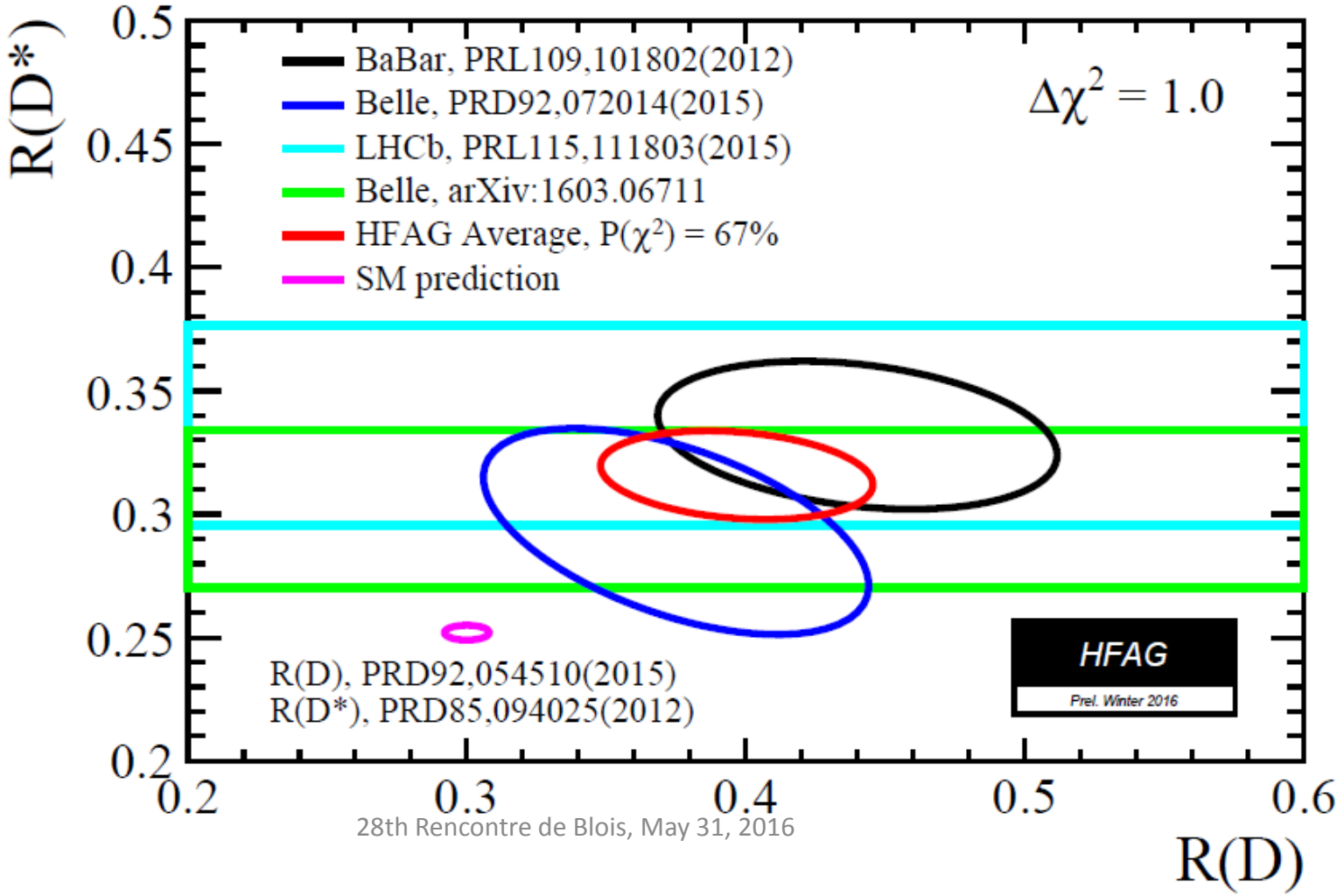
(b)Type II 2HDM with $\tan\beta/m_{H^+} = 0.7\ \mathrm{GeV}^{-1}$.



(c)R_2 type leptoquark model with $C_T = +0.36$.

Quite interesting look at the INSIDE of these events:
leptoquark hypothesis disfavored!

New HFAG average containing this result (green). SM discrepancy goes to 4.0 σ



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

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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 4.0 σ deviation from the standard model prediction (D and D*)

- **A measurement of the branching fraction $BF(B^0 \to D^*\tau\nu)$ using $\tau \to 3\pi\nu$ at a hadronic collider normalized to $BF(B^0 \to D^*3\pi)$ may yield the observation of a further deviation from the SM. This possibility relies on a precise measurement of BF(B0 → D*3π), 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

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Experimental Technique

- We use a sample of 470.9 x 10^6 pairs of B mesons

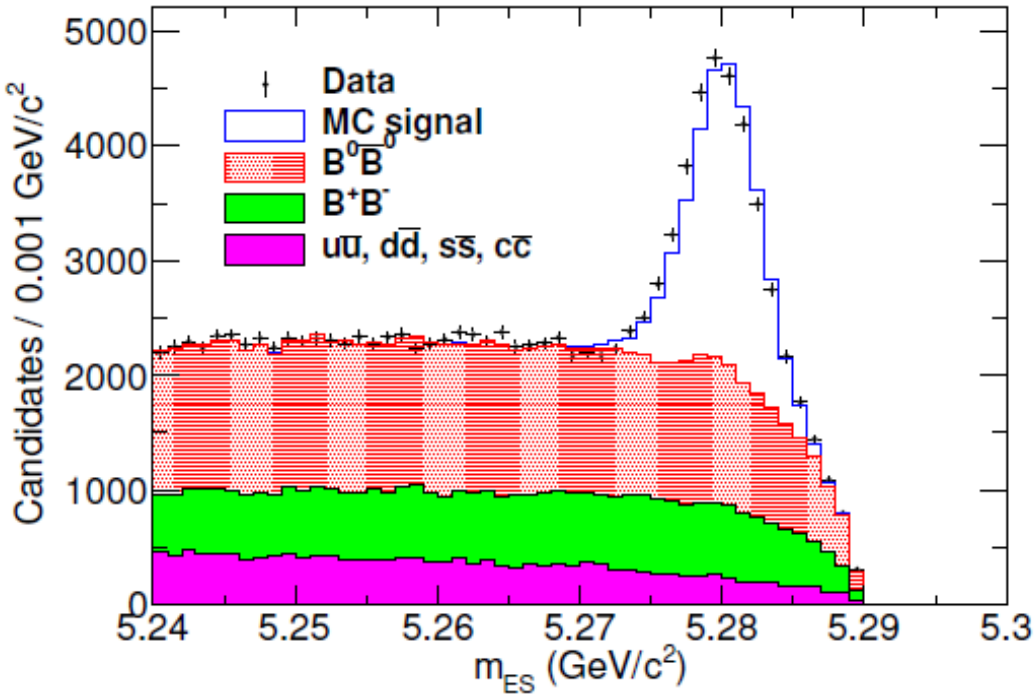
- Fully reconstruct the decay $B^0 \to D^{*-}\pi^+\pi^-\pi^+$, where

$$D^{*-} \to \overline{D}^0\pi^-, \overline{D}^0 \to K^+\pi^-$$

- We apply loose kinematic selection criteria

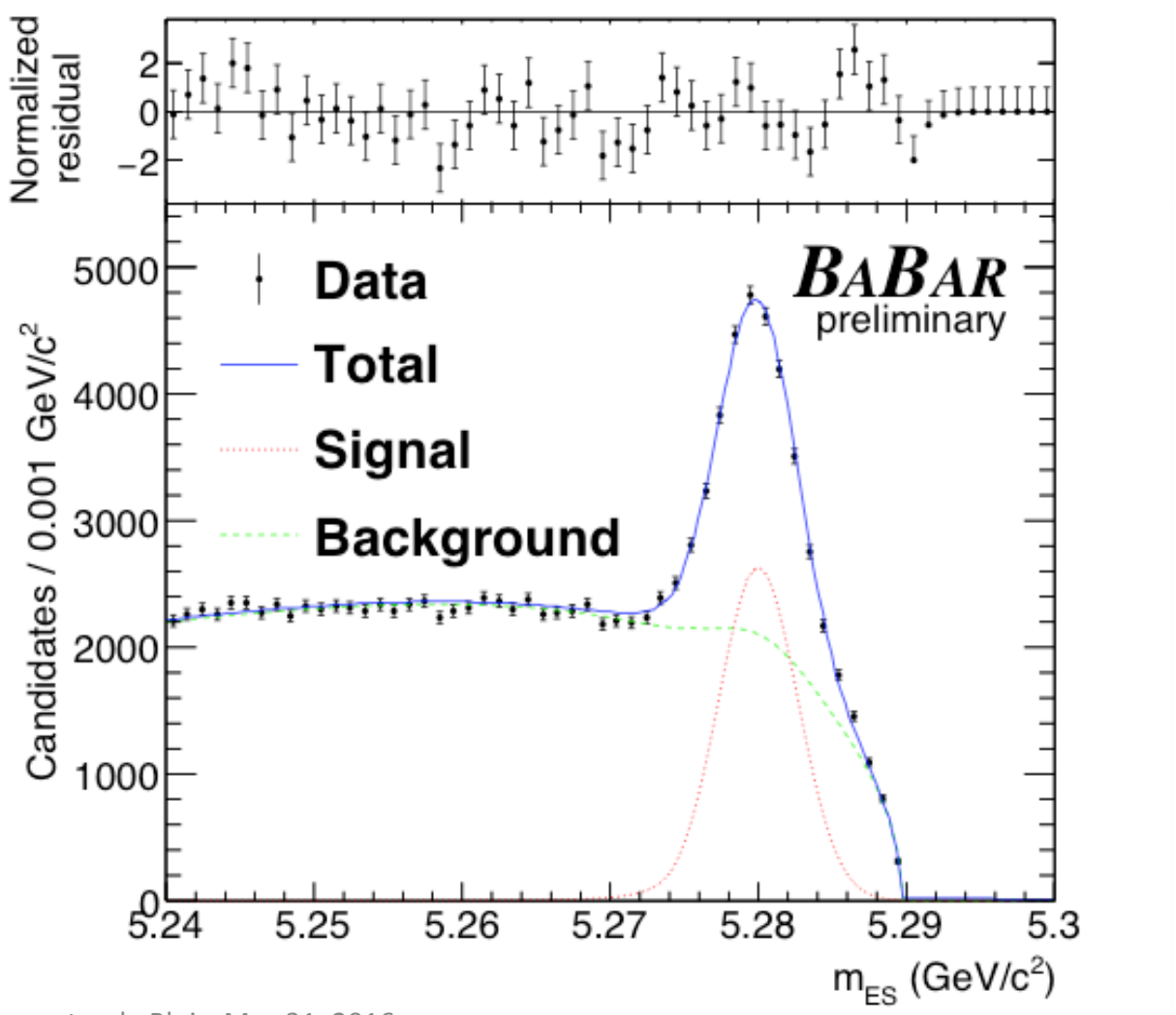
- Use MC-simulated events to study backgrounds and signal reconstruction efficiencies

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



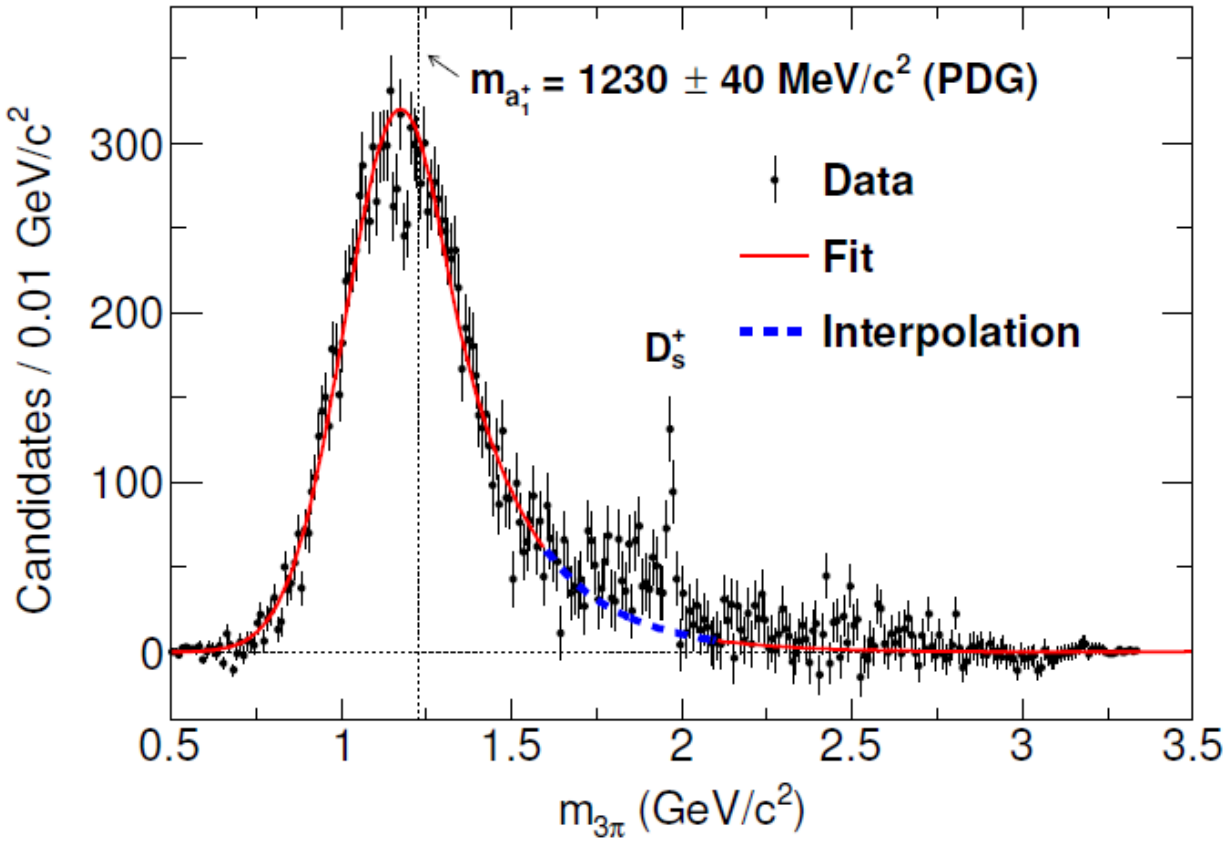
Signal Extraction

- 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

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

(singly-charmed B decays only)

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

(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%
decay branching fraction	1.2%
K^+ identification	1.1%
MC statistics	0.9%
counting	0.6%
Total	4.3%

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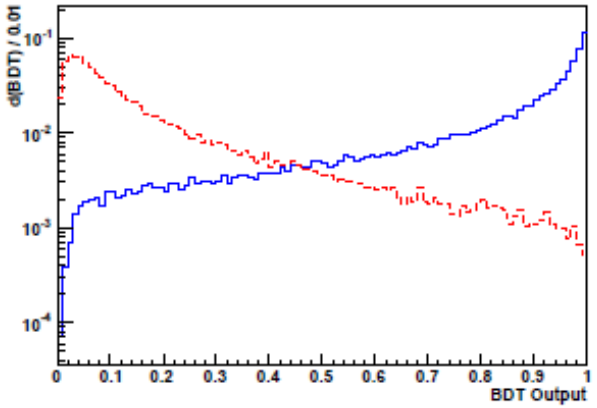
BABAR analysis of K*l^+l^-

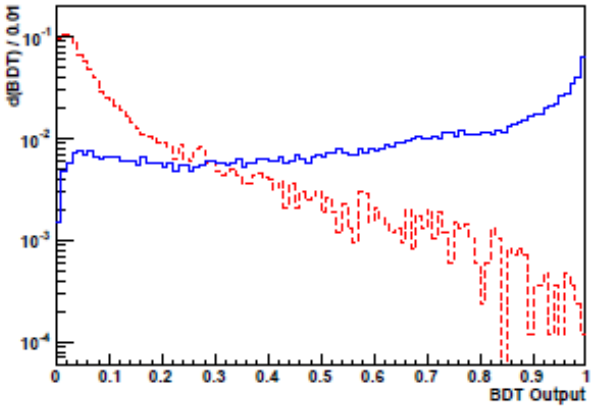
arXiv 1508.07960
Phys Rev D 93 052015 (2016)

Event selection based on a powerful Neural Net selector
Large potential background from B events and udcs events

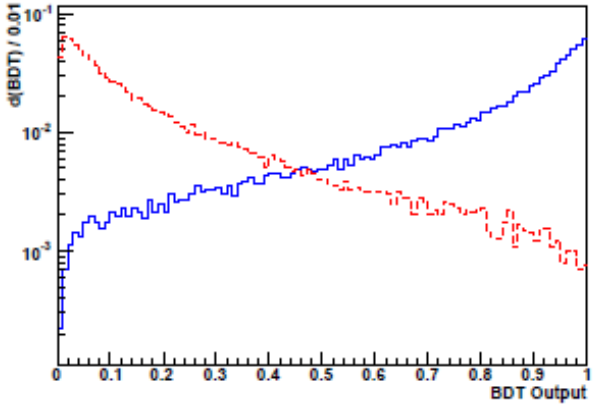
BABAR study based on B^0 and B+, e+e-, mu+mu-, K-pi+ and K0pi+



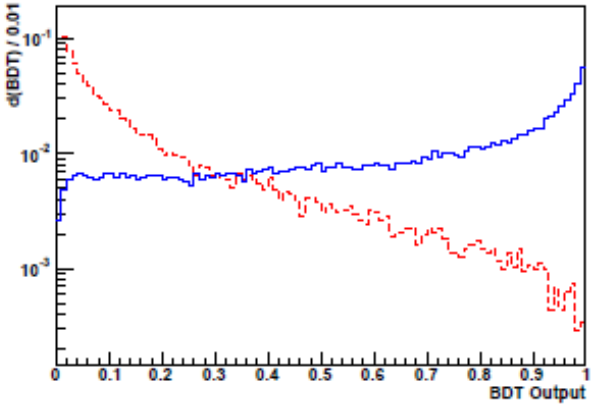
(a) e^+e^- BDT output for $B\overline{B}$ background suppression in $B^+ \to K^0_S\pi^+e^+e^-$.



(b) e^+e^- BDT output for $q\overline{q}$ background suppression in $B^+ \to K^0_S\pi^+e^+e^-$.

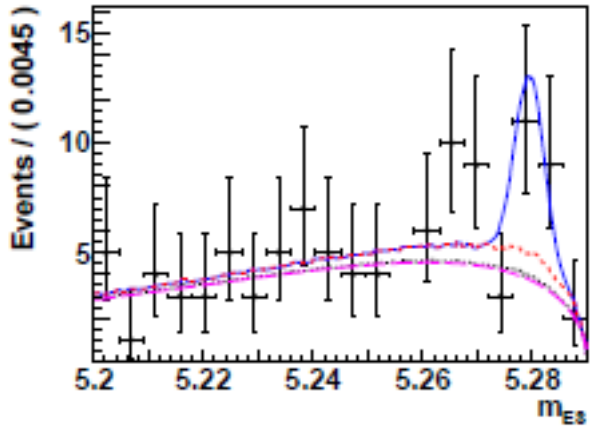


(c) $\mu^+\mu^-$ BDT output for $B\overline{B}$ background suppression in $B^+ \to K^0_S\pi^+\mu^+\mu^-$.

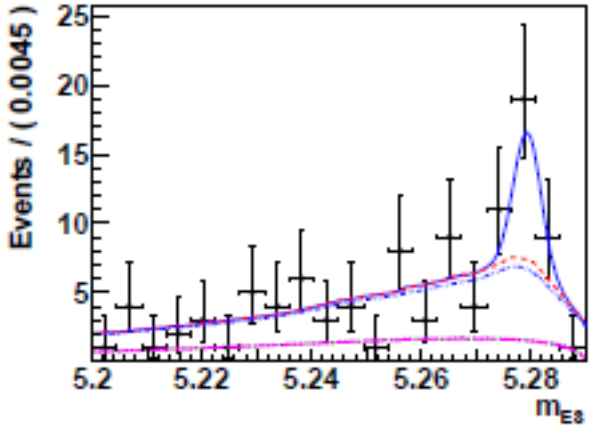


(d) $\mu^+\mu^-$ BDT output for $q\overline{q}$ background suppression in $B^+ \to K^0_S\pi^+\mu^+\mu^-$.

BABAR yields ~240 events for B^+ and B^0



(a) $m_{\rm ES}$: $B^0 \to K^+\pi^- e^+ e^-$.

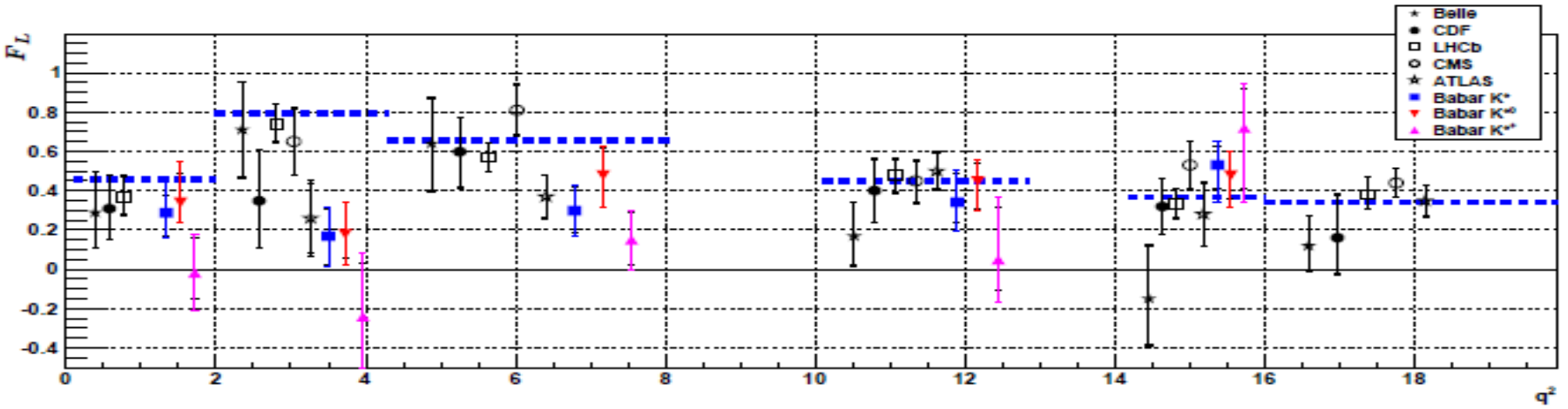


(d) $m_{\rm ES}$: $B^0 \to K^+\pi^-\mu^+\mu^-$.

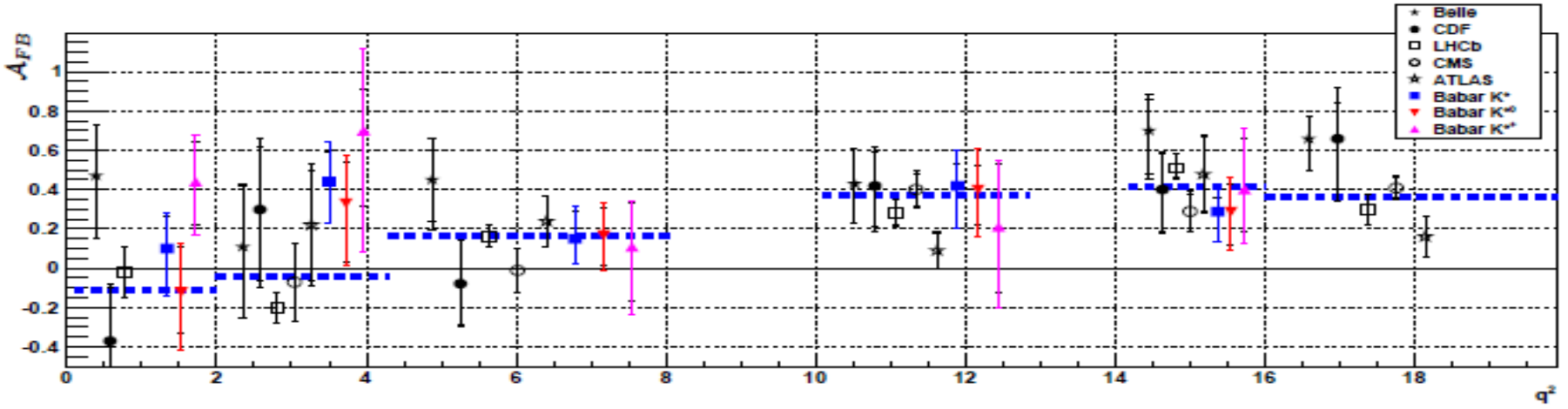
TABLE I. Fitted yields and statistical error for signal ($n_{\rm sig}$) and background ($n_{\rm bkg}$) events in the binning of q^2 for both the combined electron and muon channel.

Bin	q^2 range in GeV$^2/c^4$	$n_{\rm sig}$	$n_{\rm bkg}$
0	$1.00 - 6.00$	49.5 ± 8.4	30.3 ± 5.5
1	$0.10 - 4.00$	30.9 ± 7.4	26.4 ± 5.1
2	$4.00 - 8.00$	49.8 ± 9.3	35.6 ± 6.0
3	$10.09 - 12.90$	39.6 ± 8.0	19.3 ± 4.4
4	$14.18 - 19.00$	56.5 ± 8.7	16.0 ± 4.0

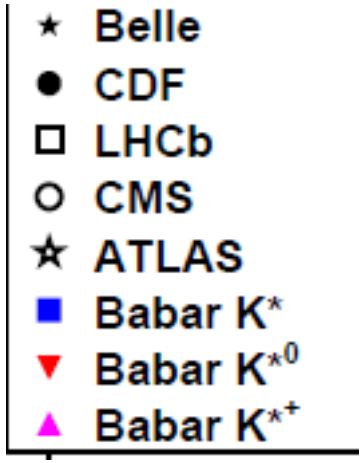
BABAR results for F_L and A_{fb}



(a) F_L.



(b) A_{FB}.



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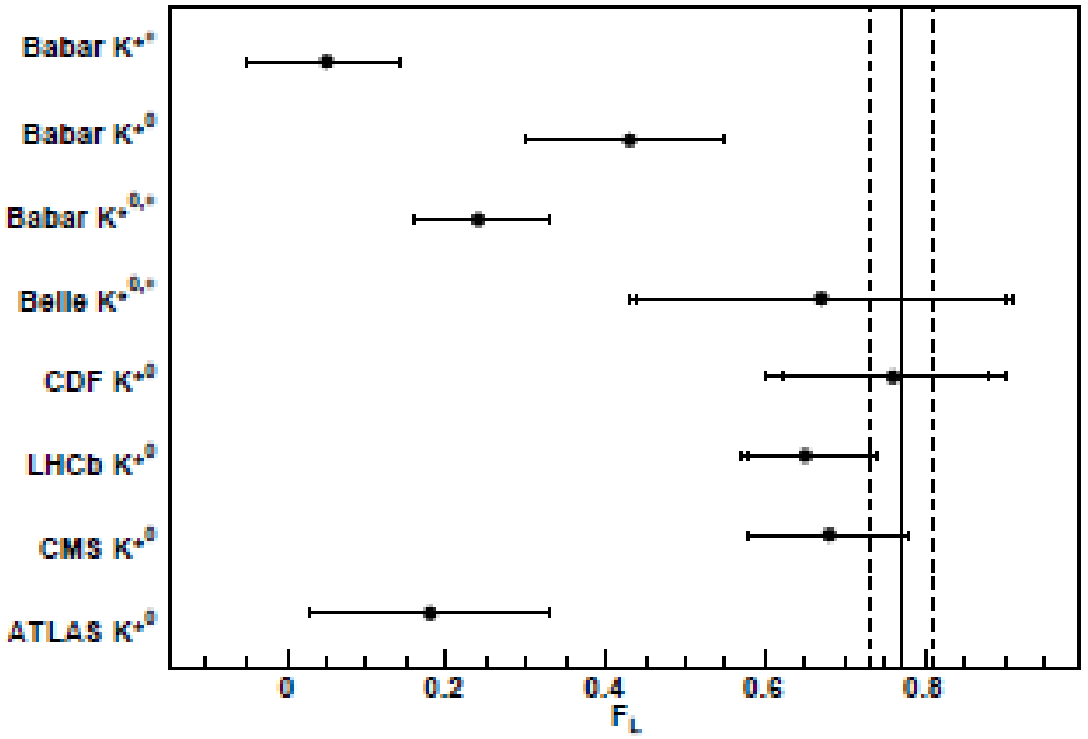
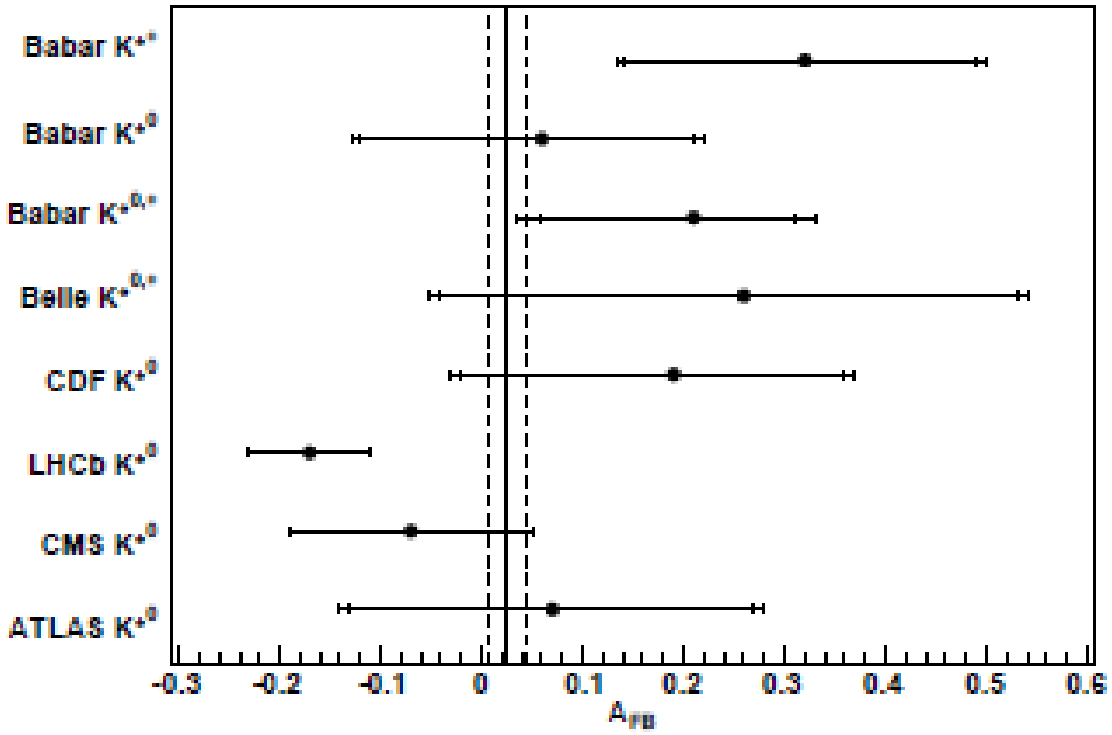
Summary of BABAR Results

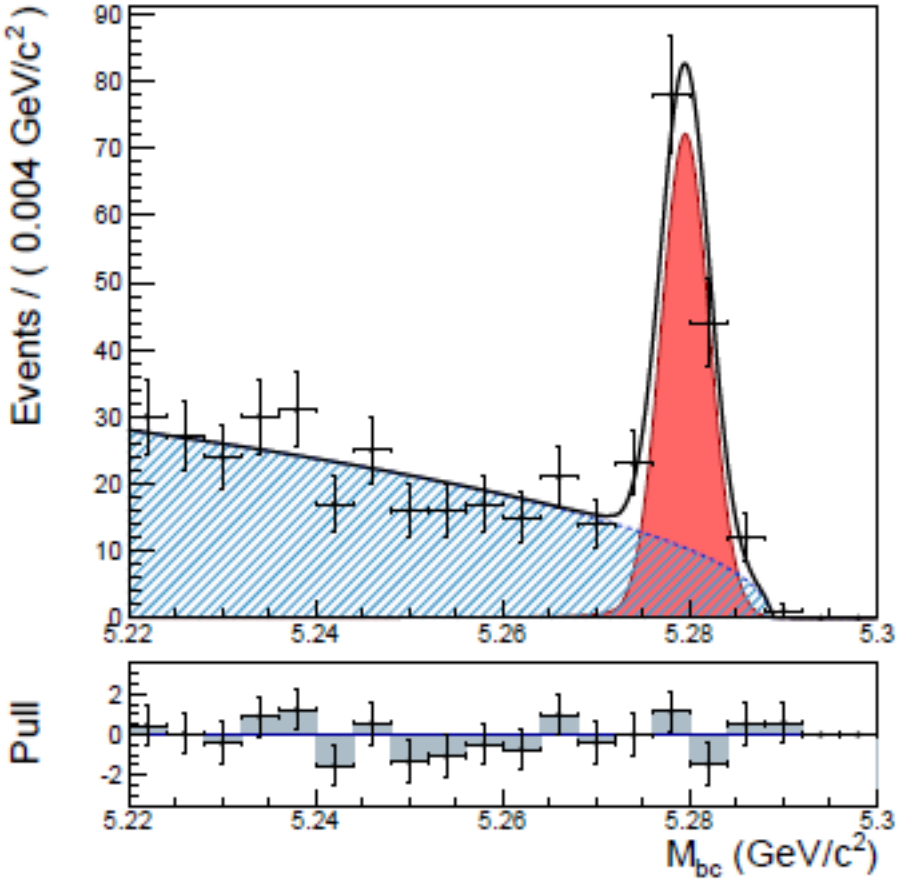


(a) F_L.

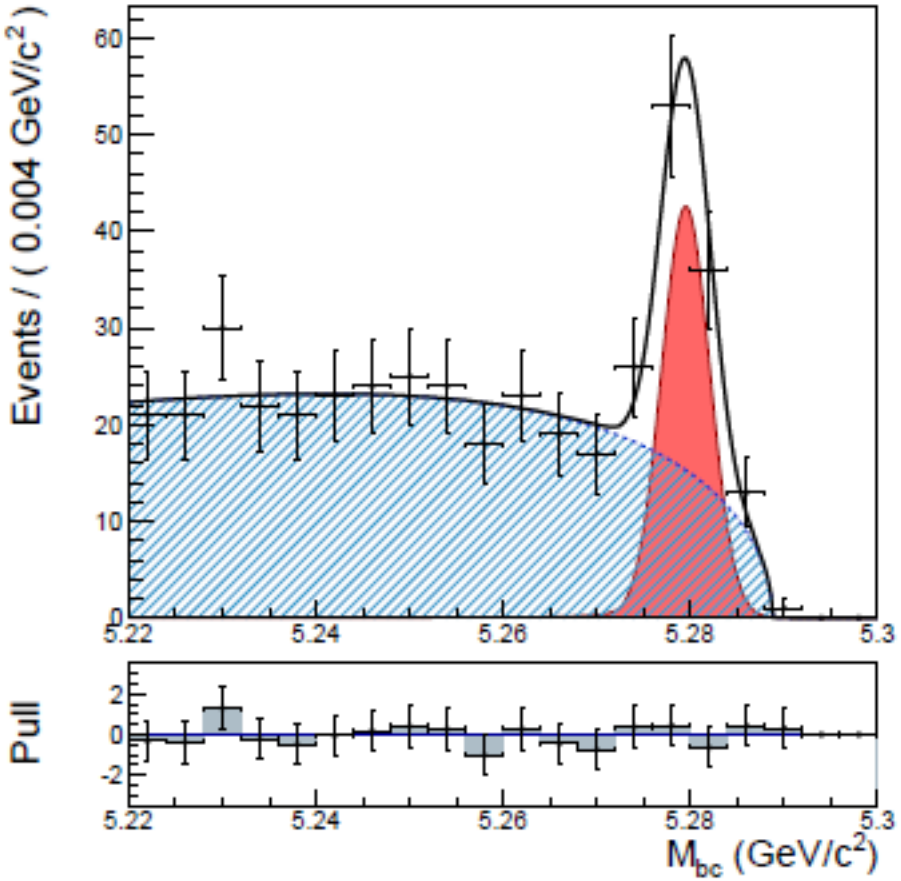


(b) $\mathcal{A}_{FB}$.

BELLE study of B->K*l+l- https://arxiv.org/abs/1604.04042



(a) $B^0 \to K^*(892)^0 \mu^+ \mu^-$



(b) $B^0 \to K^*(892)^0 e^+ e^-$

Systematic Uncertainties

TABLE III. Summary of all systematic uncertainties for P_5'.

Bin	0	1	2	3	4
Peaking Background	0.0901	0.0636	0.0078	0.0498	0.0131
Data/MC Difference	0.0112	0.0067	0.0208	0.0142	0.0029
Efficiency Correction	0.0397	0.0205	0.0098	0.0215	0.0327
Fit Bias	0.0031	0.0061	0.0430	0.0127	0.0460
Total	0.0992	0.0675	0.0494	0.0575	0.0580

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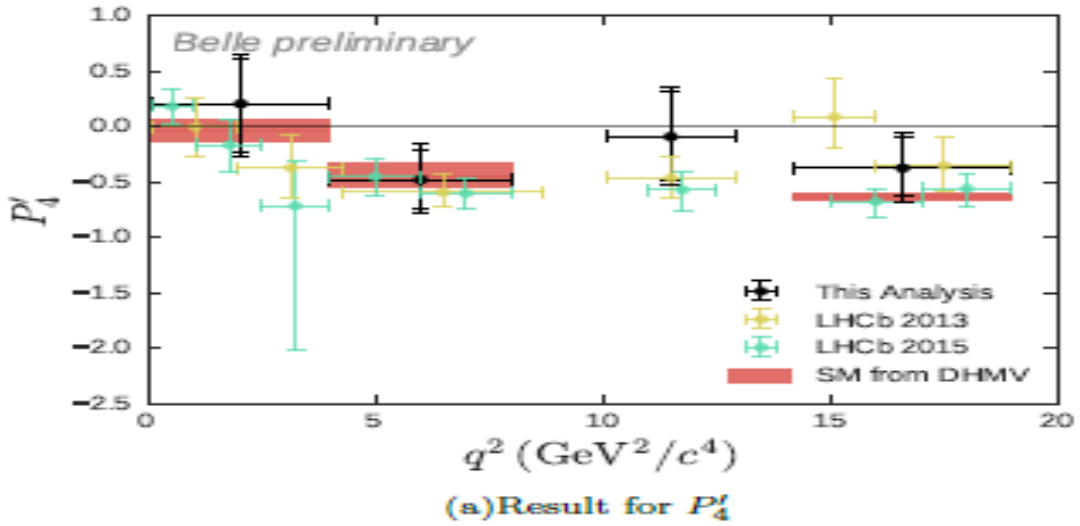
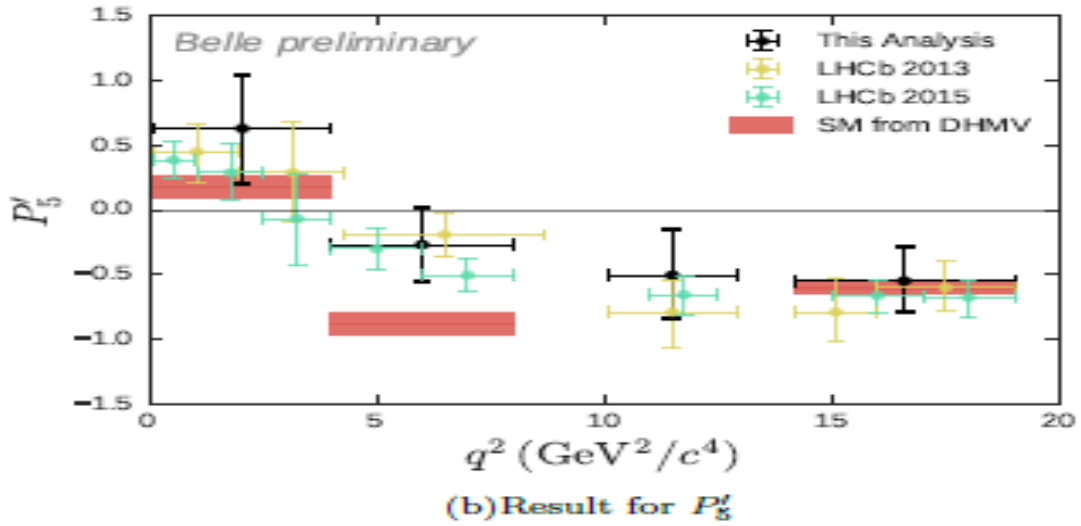
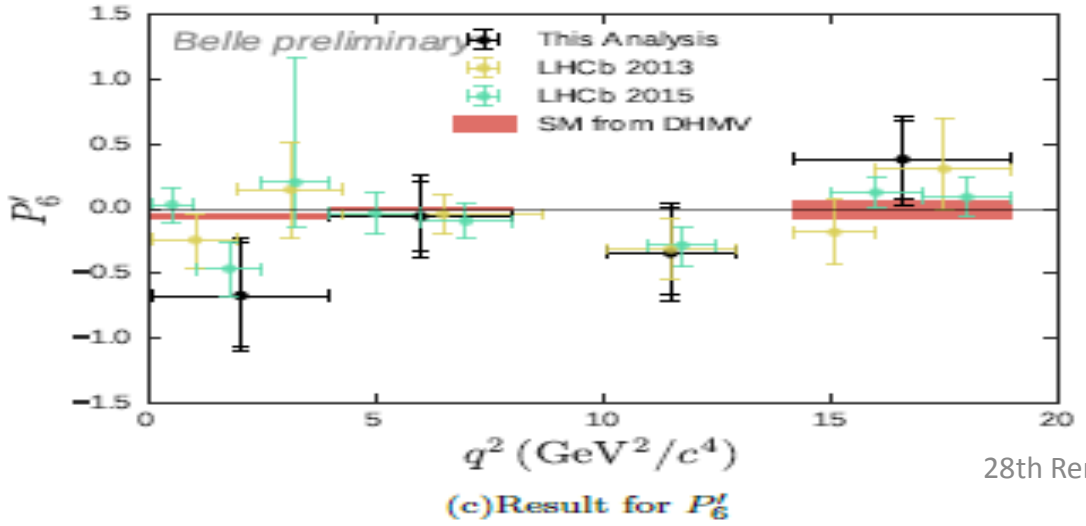
BELLE Results for P_4', P_5', P_6', P_8'



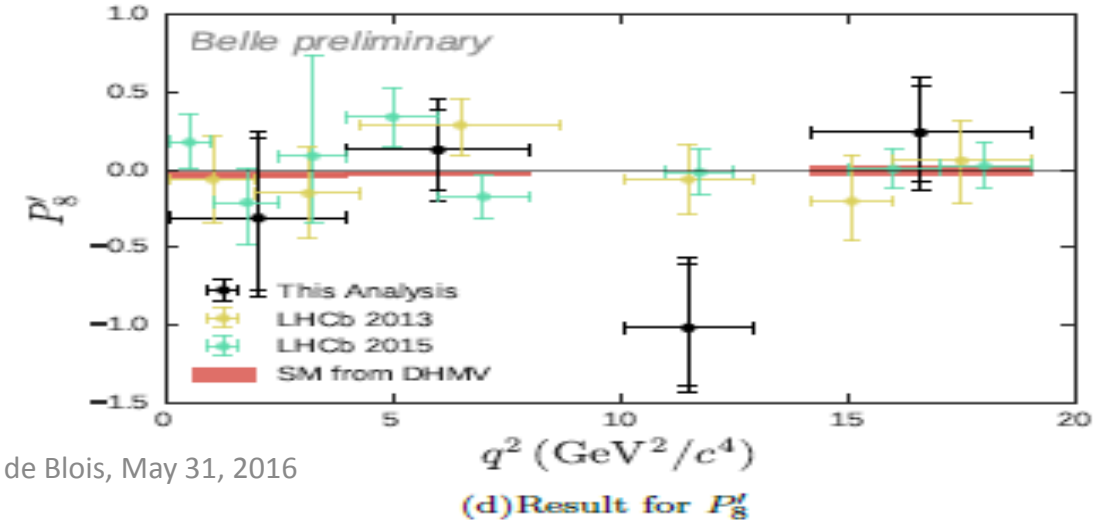
(a)Result for P_4'



(b)Result for P_5'



(c)Result for P_6'



(d)Result for P_8'

Conclusions

- B Factories experiments are still quite active to search for new physics in B decays
- $D^{*}\tau\nu$ is one of the most interesting hints, given the large discrepancy with SM expectations and the precision of SM predictions
  - New result from BELLE 1.6 σ away from SM, making the HFAG average at 4.0 σ from SM prediction.
  - New BABAR precision measurement of B^{0}->$D^{*}3\pi$ opening the way for other future precise measurements of B-> $D^{*}\tau\nu$
- $K^{*}l^{+}l^{-}$ is also rich in intriguing hints : angular observations (P_5') and LHCb hints of $Ke^{+}e^{-}$ different from $K\mu^{+}\mu^{-}$

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