

LEP II A_{FB}(b,c) Analysis

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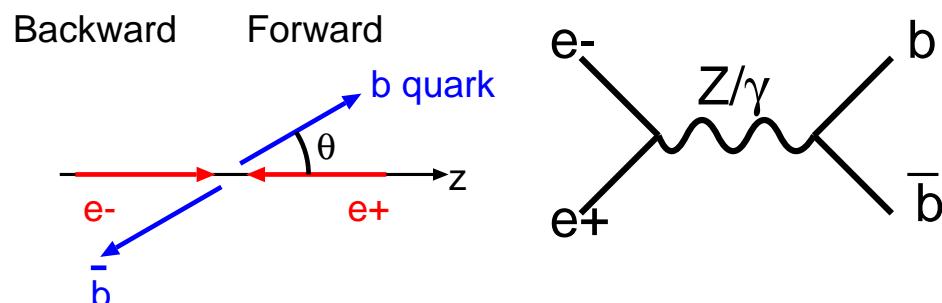
Introduction

- A_{FB}^b

$$A_{FB} = \frac{\sigma_F - \sigma_B}{\sigma_F + \sigma_B}$$

angular distribution :

$$\frac{d\sigma}{d \cos \theta} \propto 1 + \cos^2 \theta + \frac{8}{3} A_{FB} \cos \theta$$

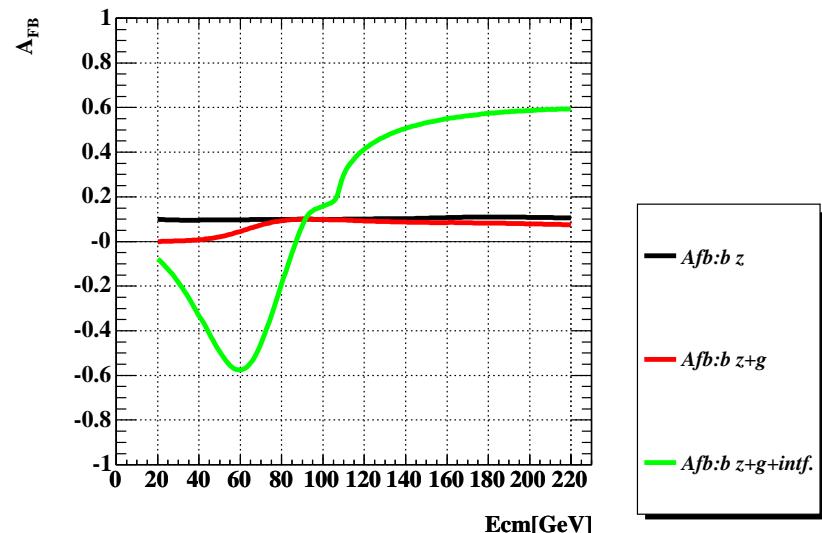


- The origin of the asymmetry

- $\gamma - Z$ interference
- Z intrinsic
- ISR-FSR interference

The $\gamma - Z$ interference is the main part above Z .

ZFITTER calculation($\sqrt{s'/s} \geq 0.85$) →



- Motivation

Standard Model prediction ($\gamma - Z$ interference)

Beyond the Standard Model (Additional diagrams to the interference.) Z' , leptoquark, ...

Analysis Overview

- Event pre-selection

- Multi-hadronic event selector
 - 98% selection efficiency for quark pair events
 - impurity: 15% four fermion, 2% two photon
- Non-radiative event selector
 - S' estimation $\rightarrow \sqrt{S'/S} \geq 0.85$
 - 95% selection effi. and 4% radiative events contami.
- Four fermion event rejection
- $|\cos \theta_{\text{thr}}| < 0.9$

90% selection efficiency for quark pair ($\sqrt{S'/S} \geq 0.85$)

6% impurity from 4 fermion

Biases on A_{FB} and R values are negligible.

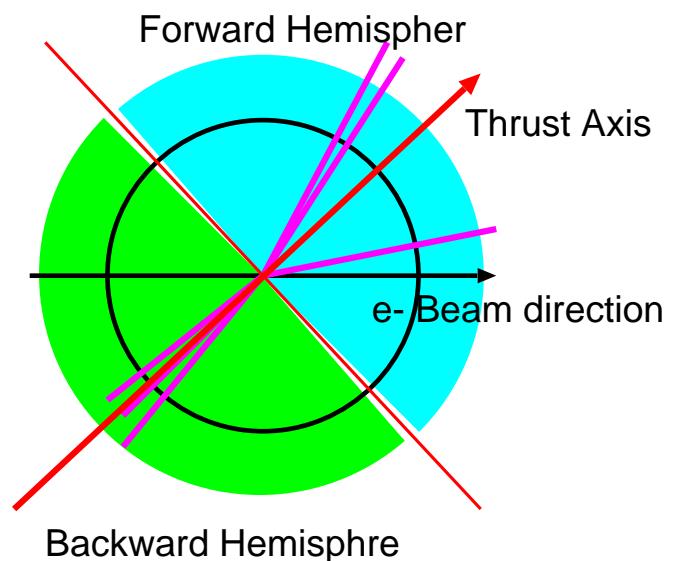
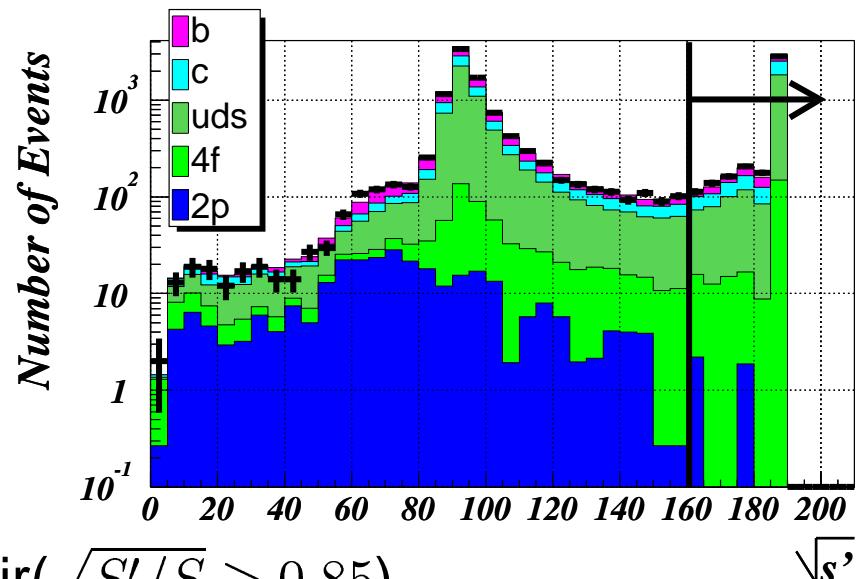
- Initial quark direction \rightarrow Thrust axis

- Charge Identification \rightarrow Hemisphere/Lepton charge

- B,c tagging \rightarrow Inclusive(mainly vertex)/Lepton

- $A_{\text{FB}}^{b,c,dus}$ Fit \rightarrow Unbinned likelihood fit for the angular dist.

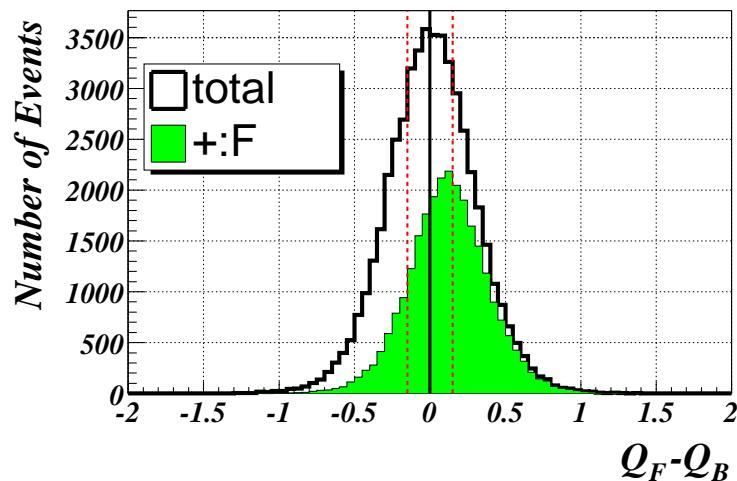
189GeV Data & MC after hadronic event selection



Inclusive Analysis~charge ID and b-tag~

- Hemisphere charge

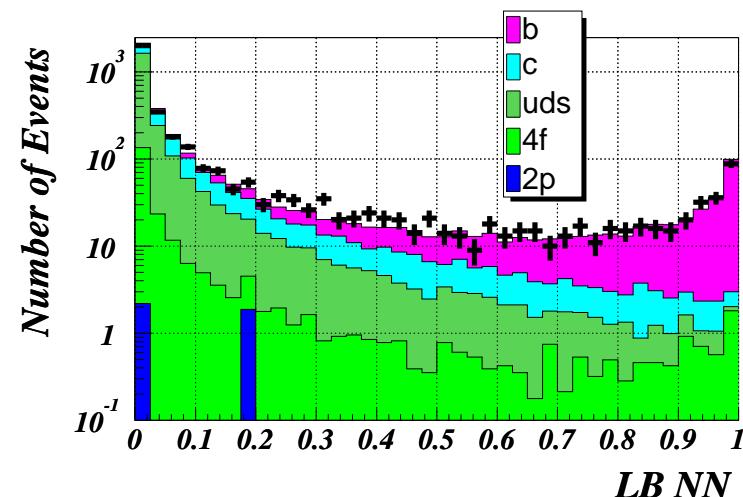
$$Q_{\text{Hemi.}} = \frac{\sum_{\text{Hemi.}} p_{\parallel}^k \times Q_{\text{track}}}{\sum_{\text{Hemi.}} p_{\parallel}^k} \quad (k = 0.4)$$



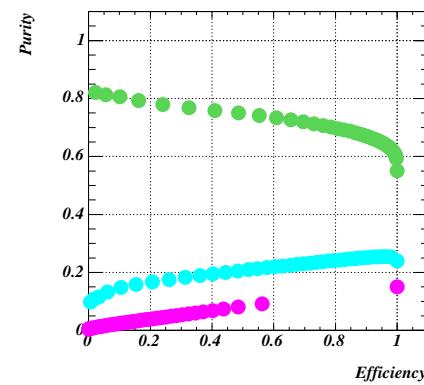
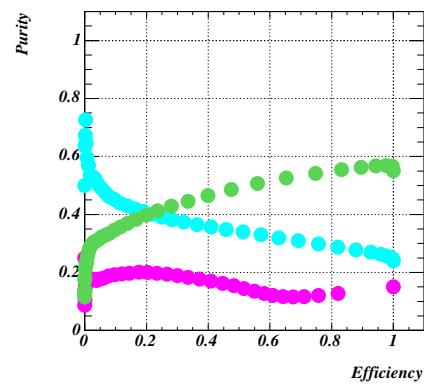
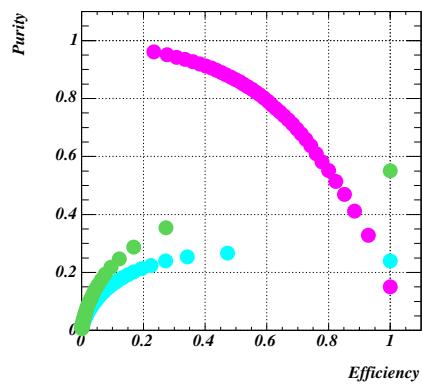
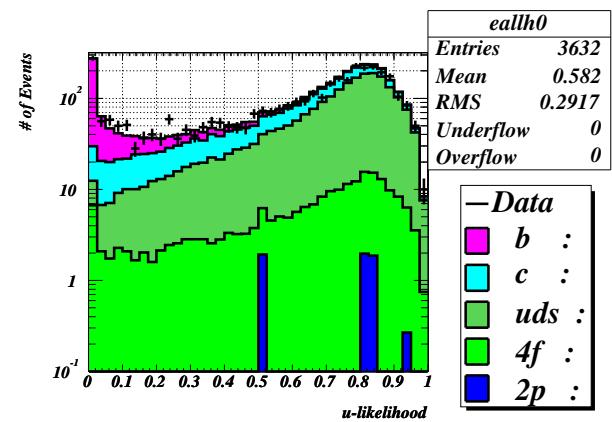
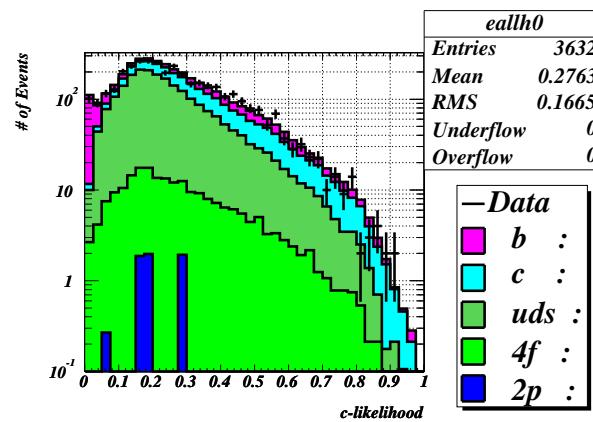
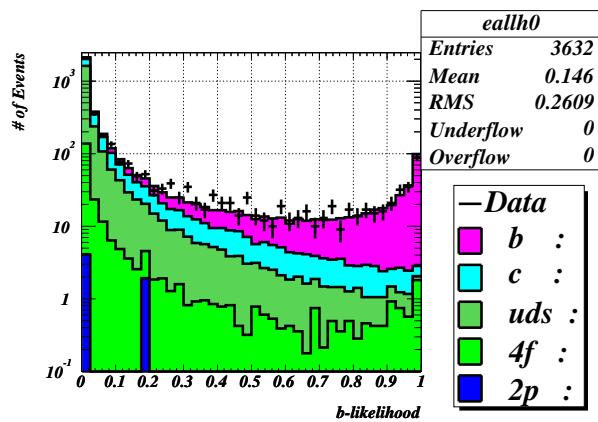
charge ID Prob.=74% (outer),60%(inner) for b

- B tag

- Vertex
- Impact parameter
- 2ndary vertex
- Semileptonic decay Lepton(p, p_t)
- Kinematics(C-parameter)



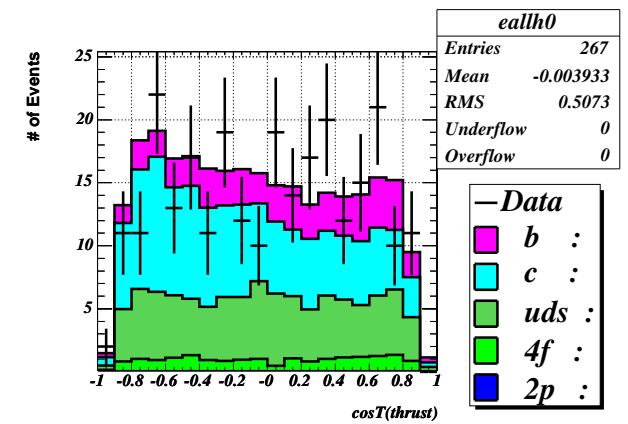
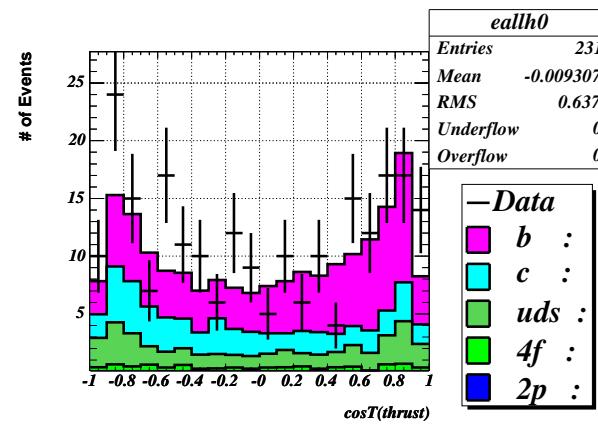
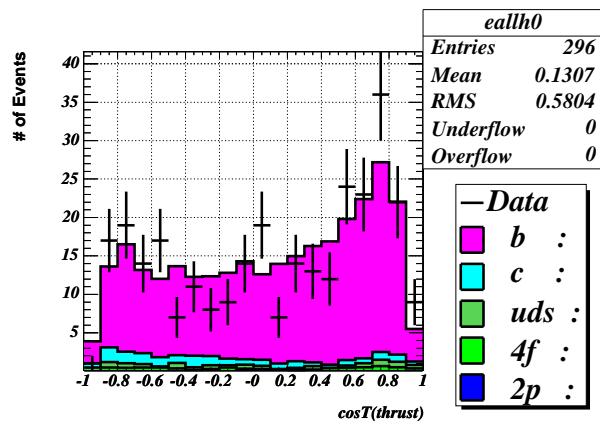
Inclusive Analysis~ $\sim b,c,d$ us likelihood~



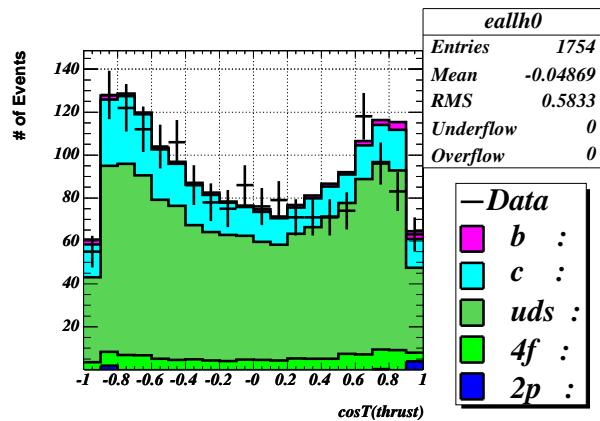
Class1:: $L_b > 0.7$, Class2:: $L_b < 0.7 \& L_b > 0.35$, Class3:: $L_b < 0.35 \& L_c > 0.55$,

Class4:: $L_b < 0.35 \& L_c < 0.55 \& L_{uds} > 0.7$

Inclusive Analysis~Fitting~



subsample $2(\text{chargeID}) \times 4(\text{bttag}) \times 3(|\cos \theta| \text{ bin})$



$$\frac{d\sigma^{obs}}{dx} = \mathcal{C}'(A_{FB}^{b,c,dus,4f}) \sum_{b,c,dus,4f} R_q \epsilon^q(x) [1 + x^2 + 8./3.(2P_q - 1)s_q A_{FB}^q x]$$

$$x = -\text{sign}(Q_F - Q_B)|\cos \theta_{\text{thrust}}|$$

\mathcal{C} ... normalization factor, $s_{b,dus} = 1, s_c = -1$

efficiency $\epsilon^q(x)$ are symmetric and the function shapes are the same.

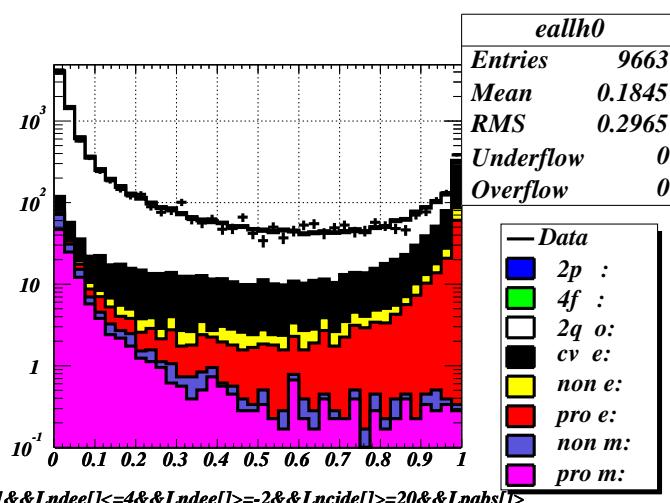
$$\rightarrow \quad pdf(x) = \mathcal{C}\epsilon(x) \left[1 + x^2 + 8./3. \sum_{b,c,dus,4f} F_q(2P_q - 1)s_q A_{FB}^q x \right]$$

$$\rightarrow \quad \log \mathcal{L} = \sum_i^{\text{events}} \log(pdf(x_i)) \rightarrow \text{maximize} \rightarrow A_{FB}^b = 0.45 + 0.15 - 0.15, A_{FB}^c = 0.46 + 0.35 - 0.35$$

Lepton Analysis~Track Selection~

- electron

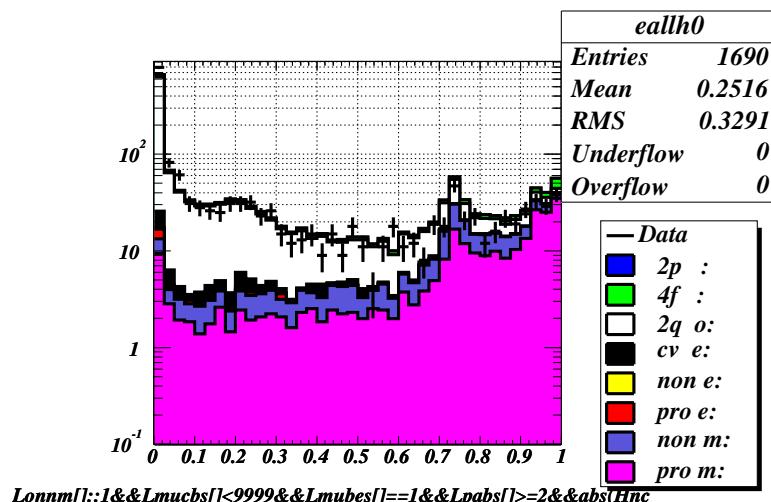
- $|P| \geq 2\text{GeV}$
- # of dE/dx samplings in $CJ \geq 20$
- $4 \geq \text{normalized } dE/dx \geq -2$
- $NN_{\text{electron}} \geq 0.9$
- $NN_{\text{conv}} \leq 0.4$ (if found)



Lonne[]::1&&Lndee[]<=4&&Lndee[]>=-2&&Lncjde[]>=20&&Lpabs[]>

- muon

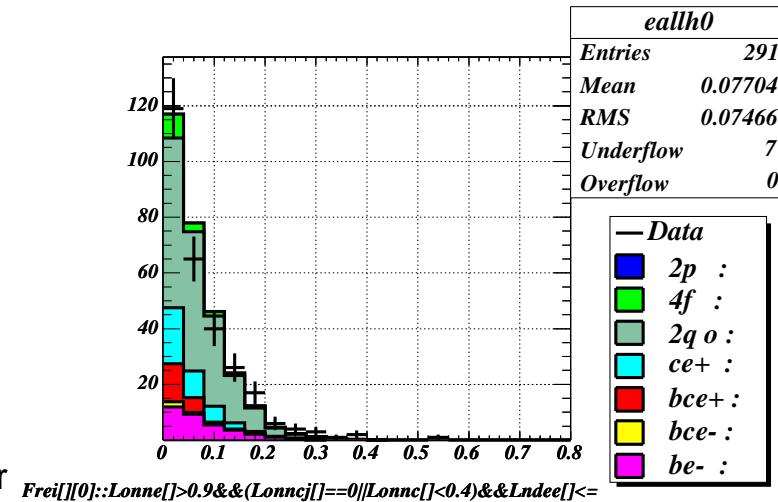
- muon segment
- $|P| \geq 2\text{GeV}$
- best matching track(muon segment-track)
- Muon NN selection ≥ 0.65



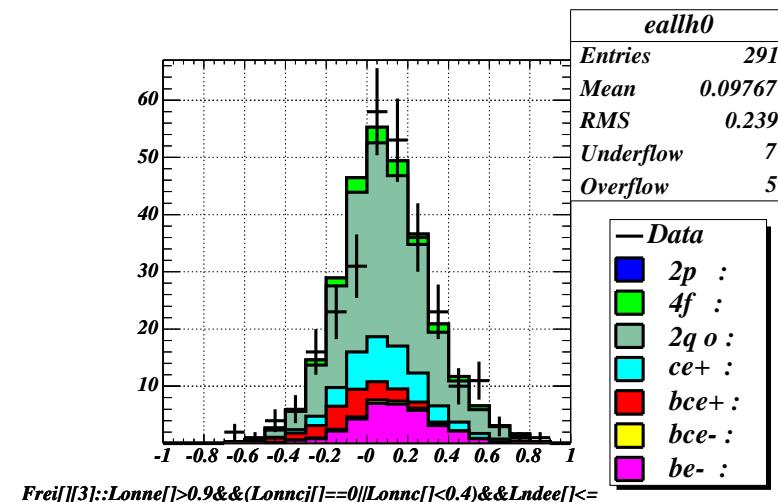
Lepton Analysis~lepton NN inputs~

- lepton scaled momentum($P/\sqrt{s'}$)
- lepton p_t w.r.t the jet axis
- decay length significance of the jet
- jetQ(contain the lepton) \times leptonQ
- $|\cos\theta_{\text{jet}}|$
- forward multiplicity of the jet
- $\text{NN}_{\text{electron}}$ (electron only)
- NN_{conv} (electron only)
- decay length significance of the jet(most energetic in other hemi.)
- jetQ(most energetic in other hemi.) \times leptonQ
- $\text{NN}_{\mu\text{on}}$ (muon only)
- Sub Jet Energy
- Jet Energy
- P_t Sum
- Impact Parameter Sig.

lepton p

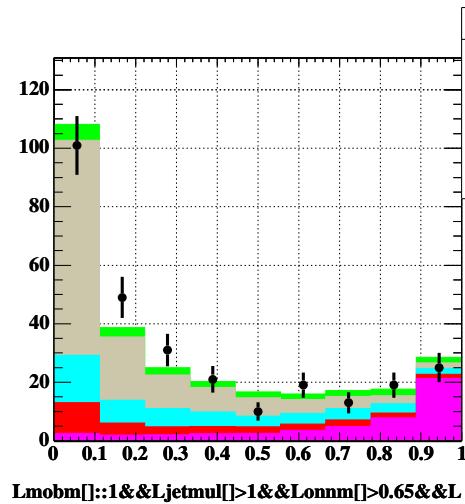


jetQ(contain the lepton) \times leptonQ

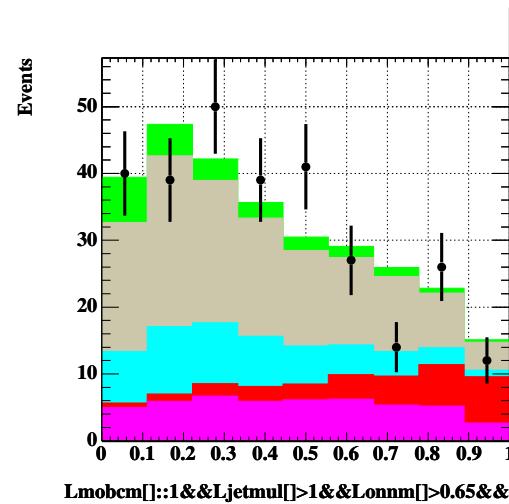


Lepton Analysis~lepton NN~

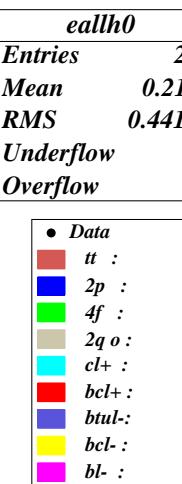
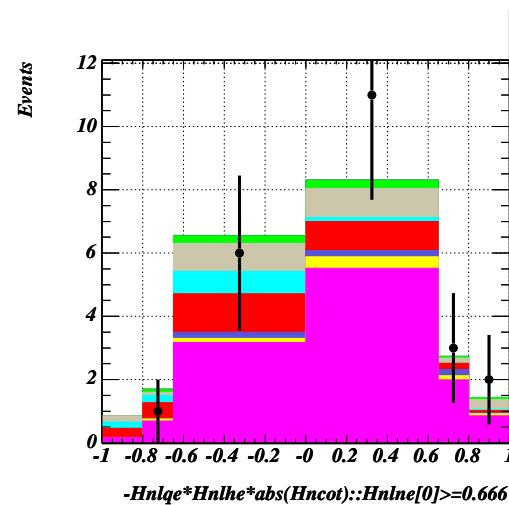
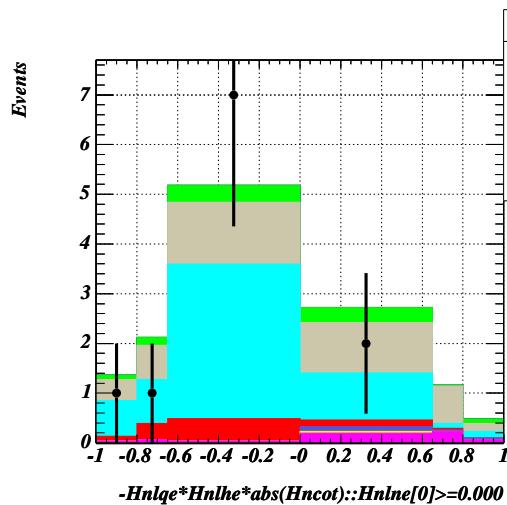
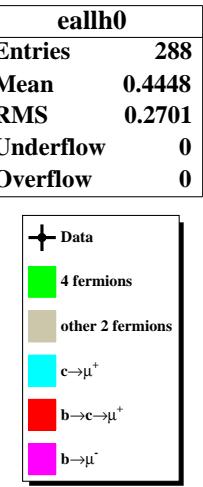
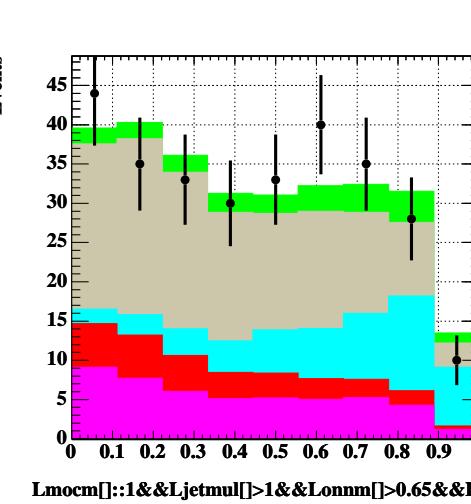
$\mathcal{N}\mathcal{N}_{\text{bm}}$



$\mathcal{N}\mathcal{N}_{\text{bcm}}$



$\mathcal{N}\mathcal{N}_{\text{cm}}$



$$\begin{aligned}
 A_{\text{FB}}^{\text{bl}-} &= A_{\text{FB}}^{\text{b}} \\
 A_{\text{FB}}^{\text{bcl}+} &= -A_{\text{FB}}^{\text{b}} \\
 A_{\text{FB}}^{\text{cl}+} &= -A_{\text{FB}}^{\text{c}} \\
 A_{\text{FB}}^{\text{other}} &= 0 \\
 \end{aligned}
 \rightarrow \text{2 parameter fit}$$

$$\rightarrow \text{pdf}(x) = \mathcal{C}\epsilon(x) \left[1 + x^2 + 8./3. \sum_q F_q (1 - 2\chi_q) A_{\text{FB}}^q x \right] \rightarrow A_{\text{FB}}^b = 0.53 + 0.23 - 0.24, A_{\text{FB}}^c = 0.25 + 0.23 - 0.23$$

Combine inclusive and lepton analysis

Define significance for each tag,

1. inclusive significance
charge ID prob. * b-likelihood
2. prompt lepton significance

$$\sqrt{NN_{bl}^2 + NN_{bcl}^2 + NN_{cl}^2}$$

Select a tag with maximum significance.

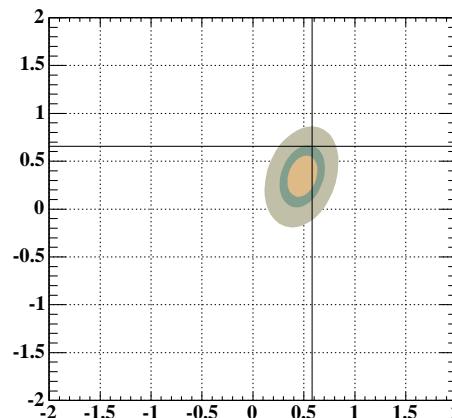
Results for 189 GeV

$$A_{FB}^b = 0.49 + 0.15 - 0.15$$

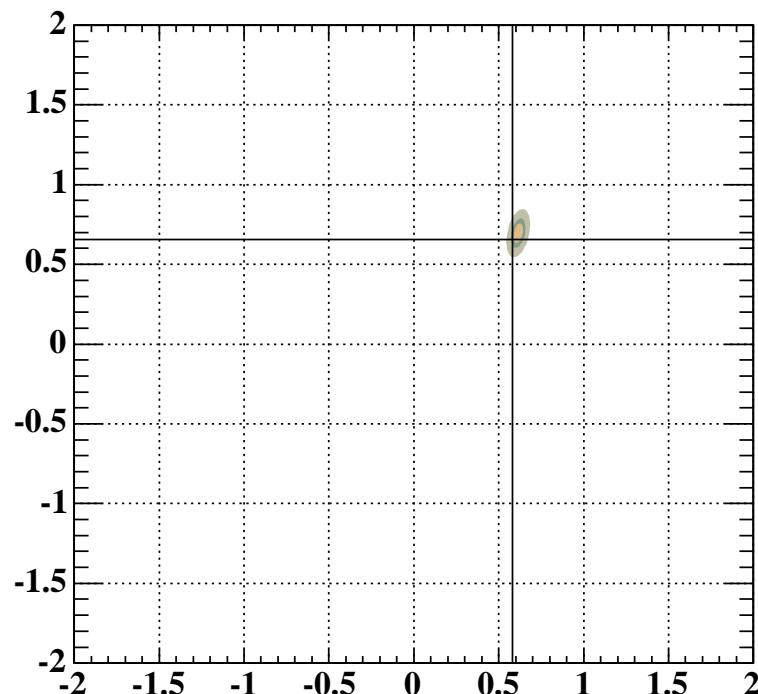
$$A_{FB}^c = 0.35 + 0.22 - 0.21$$

correlation=27%

of Vertex tag: 1041, # of Lepton tag: 432

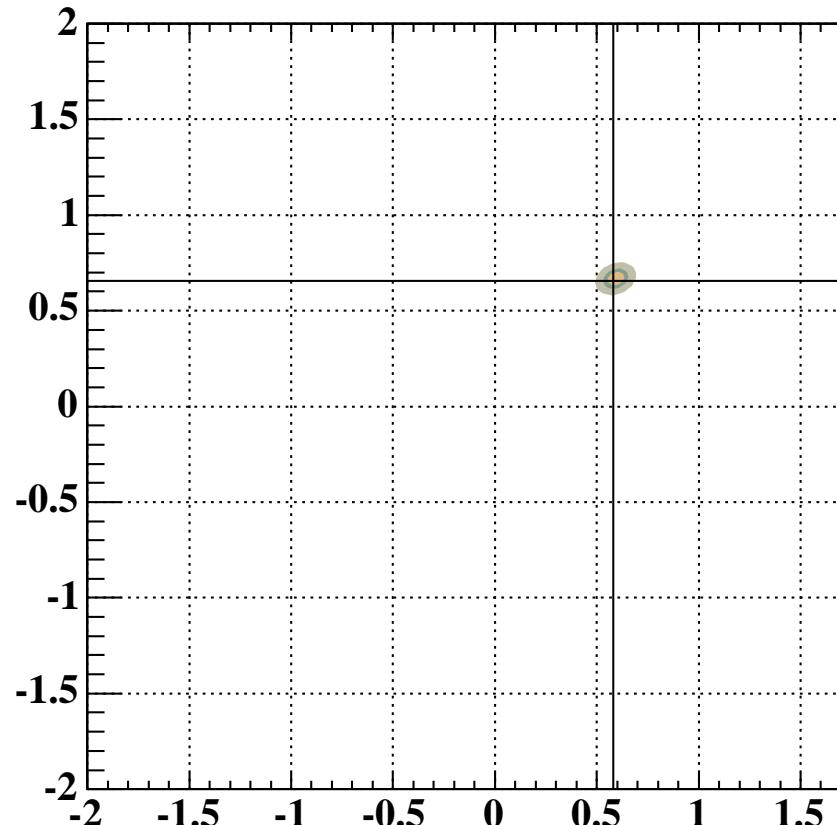
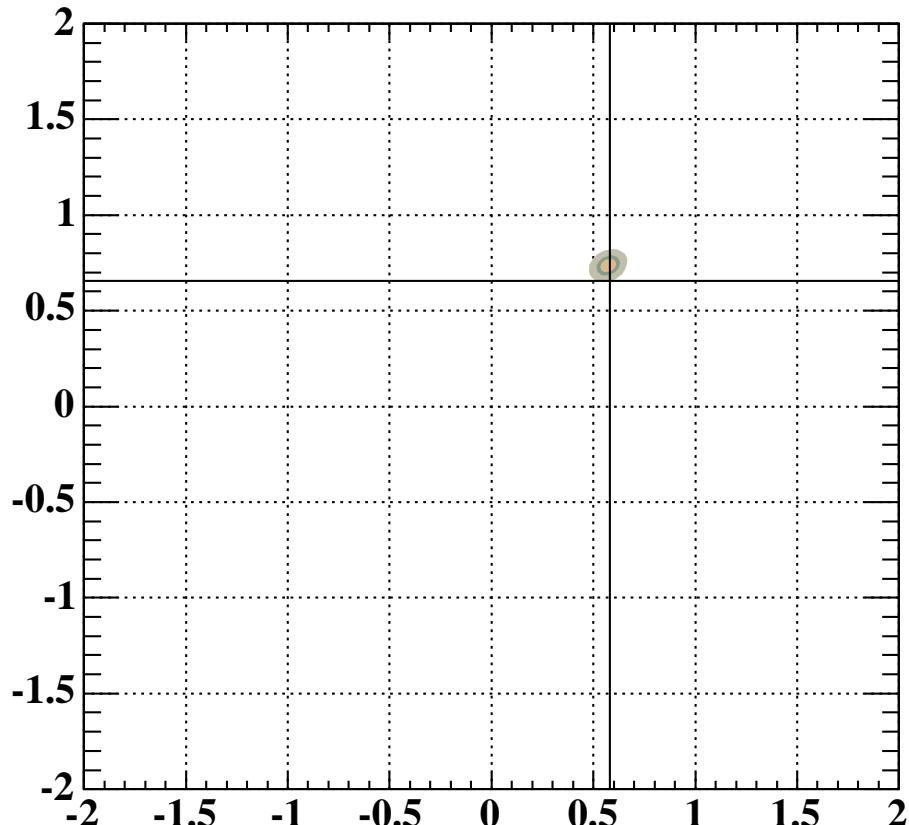


Fitting Bias



MC as Data input
Inclusive : $< 1 \sigma$
checked with Z calibration data
(within 1σ stat.error)

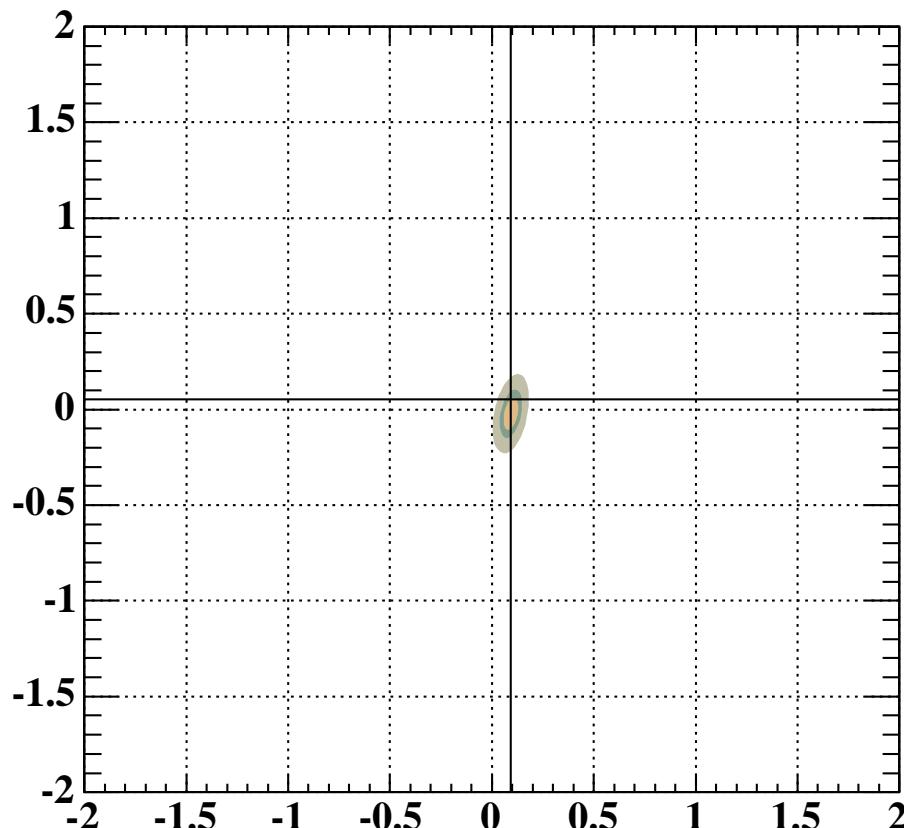
Fitting Bias



Lepton:: 2σ deviation due to the bg A_{FB}

$A_{FB}^{BG} = 0 \rightarrow A_{FB}^{BG} = -0.04 \rightarrow \Delta A_{FB}^c = 0.06$ systematic error
checked with Z calibration data(within 1σ stat.error)

Fitting Bias



Corrections and systematic errors

• Corrections

189GeV

	A_{FB}^b	A_{FB}^c
I-F interference on thrust direction	+0.006	-0.01
s' estimation	+0.004	+0.005
4f rejection	-0.022	-0.014
	+0.008	+0.009
	-0.004	-0.01

$$A_{\text{FB}}^b = 0.49 + 0.15 - 0.15 \quad (SM :: 0.58)$$
$$A_{\text{FB}}^c = 0.35 + 0.22 - 0.21 \quad (SM :: 0.66)$$

• Systematic Errors

		A_{FB}^b	A_{FB}^c
Event selection	corrections	0.03	0.03
Final state QCD effect	from zfitter	0.015	0.022
Physics Modeling	B decay mul.	0.001	0.003
Detector Modeling	Track reconstruction	0.04	0.03
Monte Carlo Statistics	Fractions	0.06	0.07
Fitting Procedure	bg A_{FB}	0.01	0.06

not completed but expected to be ~ 0.1

Summary & prospects

Summary

- $A_{\text{FB}}^{b,c}$ were measured
 - with the lepton tag in addition to the inclusive tag.
 - with no assumption on $A_{\text{FB}}^{u,d,s}$.
 - with better accuracy.
 - with reasonable agreement with SM predictions.
- Some of systematic errors were evaluated.
 - expected to be smaller than the statistical error.

Prospects

- Complete the analysis for all LEP II data.
- Evaluate remaining systematic errors.