AFB studies at 500 GeV (update)

ILD Top/HF group meeting 22/02/22

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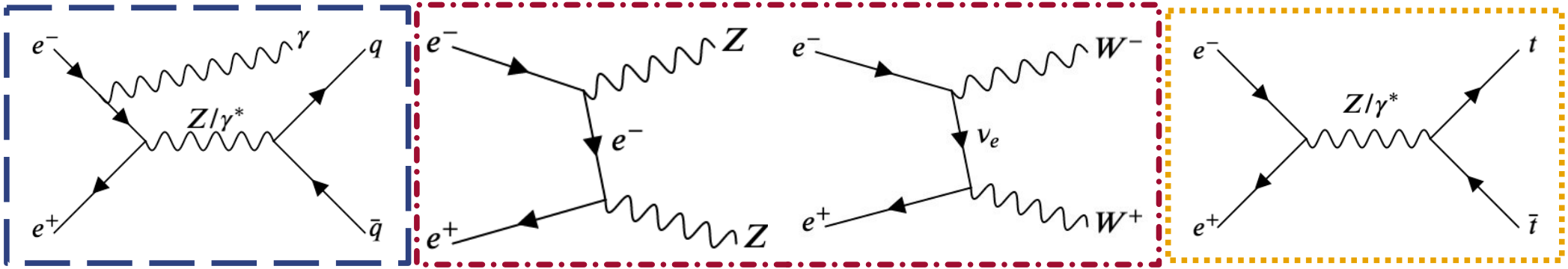
Preselection of $q\bar{q}$ signals

- Once we have the reconstructed pfos of the events with different targets:
  - We cluster the signal in jets (VLC algorithm):
    - The algorithm packs together the PFOs into two jets.
    - Signal is expected in a back-to-back topology (but not the backgrounds!)
      - Most of the background is **radiative return ($\gamma q\bar{q}$)**
      - And most of the data is background!
        - x3 for $e^-_L e^+_R$ and x6 for $e^-_R e^+_L$ at 250 GeV
        - x4 for $e^-_L e^+_R$ and x7 for $e^-_R e^+_L$ at 500 GeV
  - Then we apply different cuts to the signal to remove the background processes



Optimization of the cuts: K_{reco}

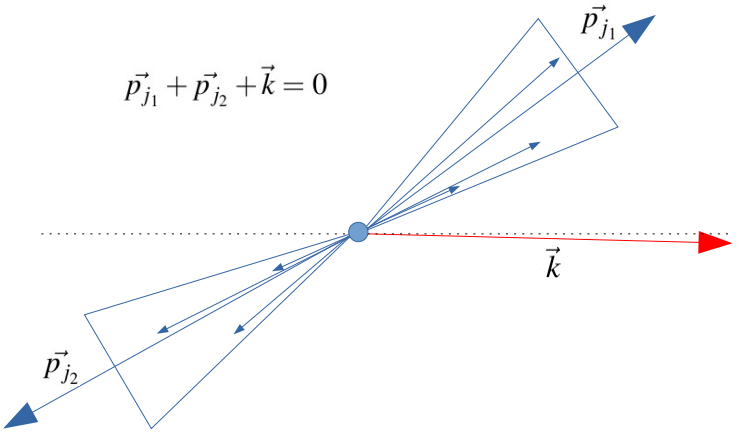
- K_{reco} is a good estimator of E_γ:
  - Definition of acolinearity:

$$\sin\Psi_{acol} = \frac{\vec{p_{j_1}} \times \vec{p_{j_2}}}{|\vec{p_{j_1}}| \cdot |\vec{p_{j_1}}|}$$

  - Momentum of the collinear photon in the ultrarrelativistic limit ($m_{jets} << p_{jets}$):

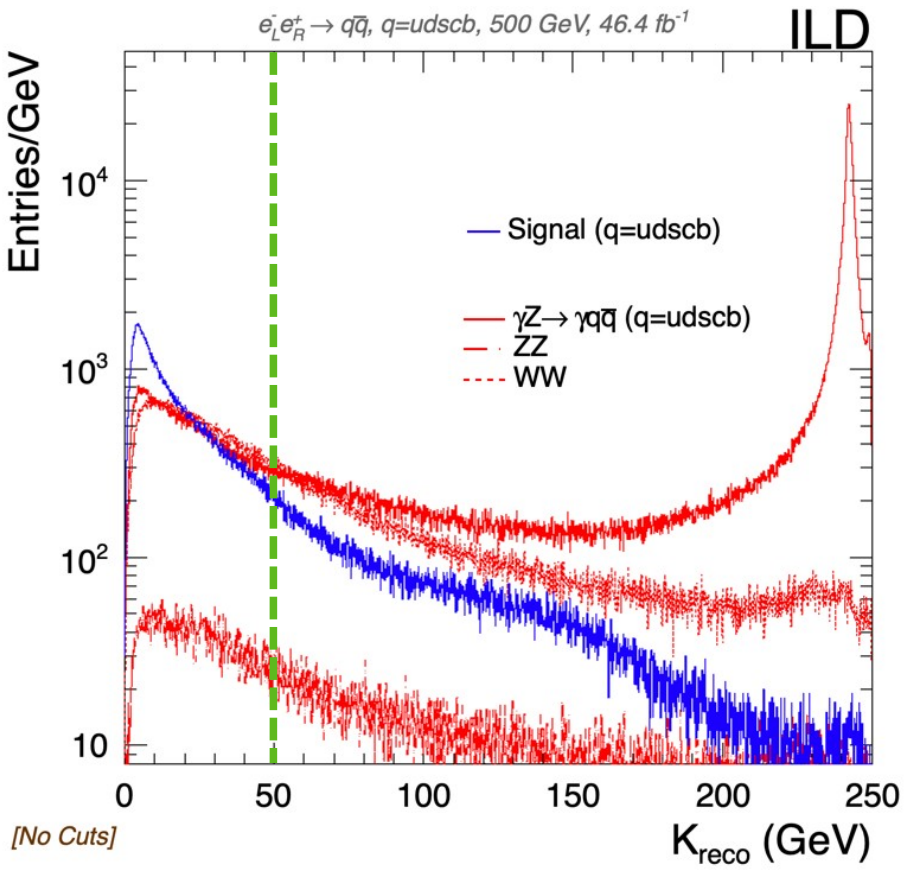
$$|\vec{k}| \approx K_{reco} = \frac{250\,\text{GeV}\,\sin\Psi_{acol}}{\sin\Psi_{acol} + sin\theta_1 + sin\theta_2}$$

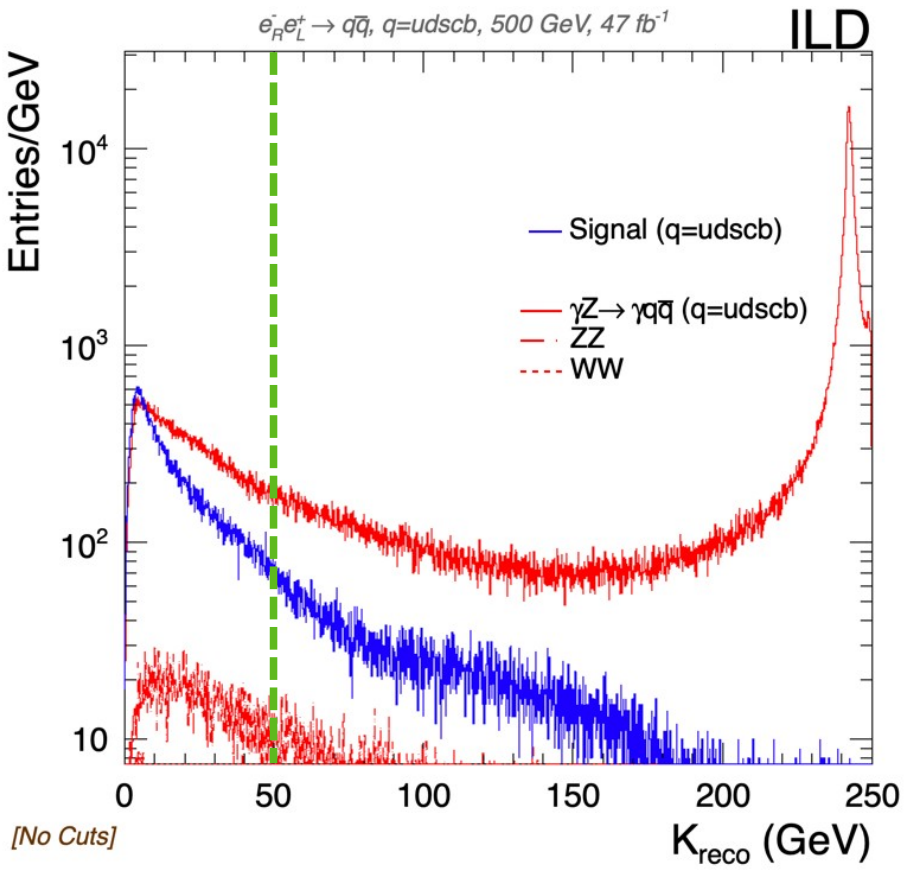
500 GeV...This typo was actually in my code!



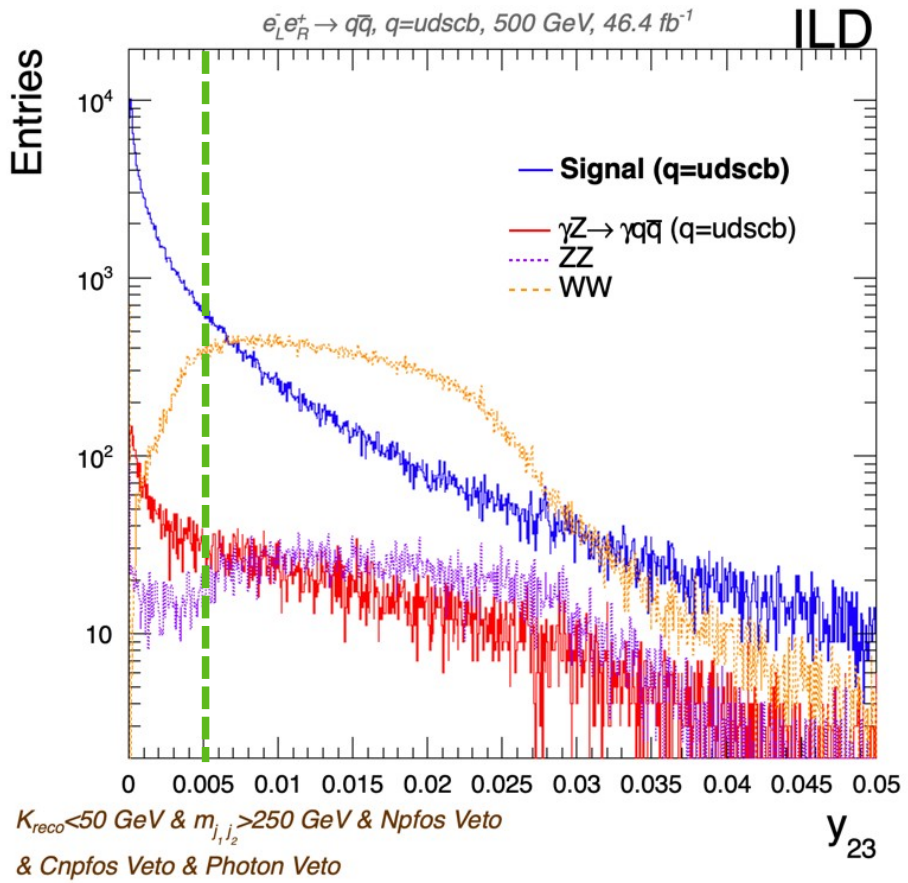
Kinematics of a two jets system reconstruction with ISR

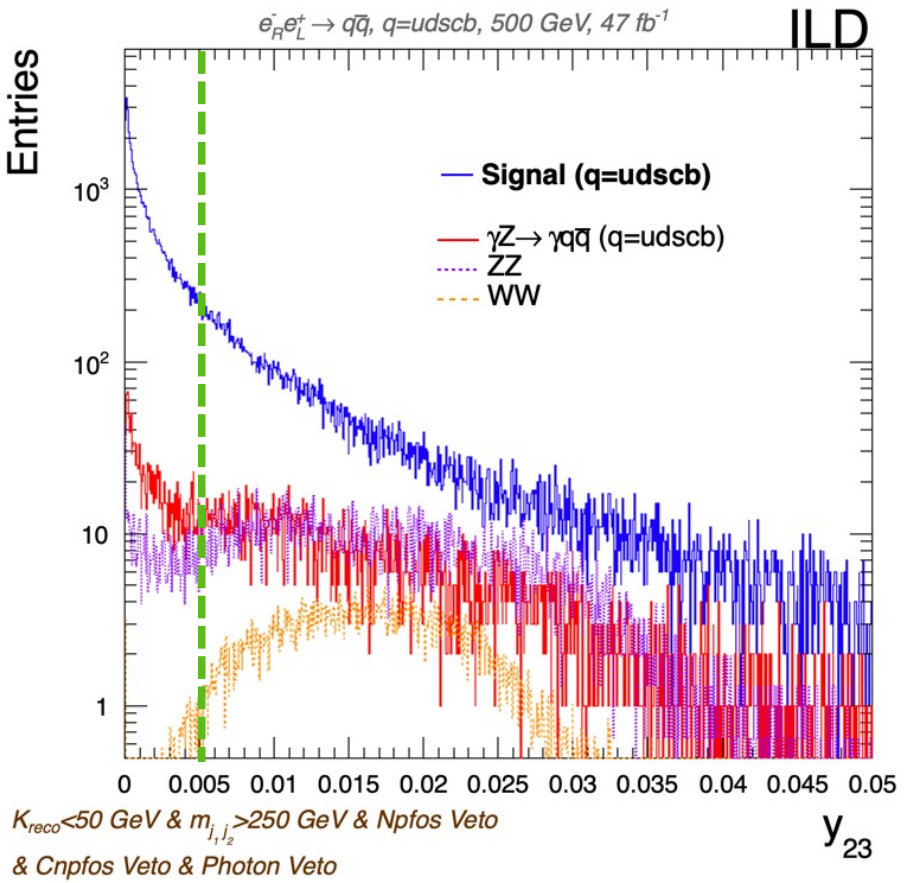
First cut: K_{reco} < 50 GeV



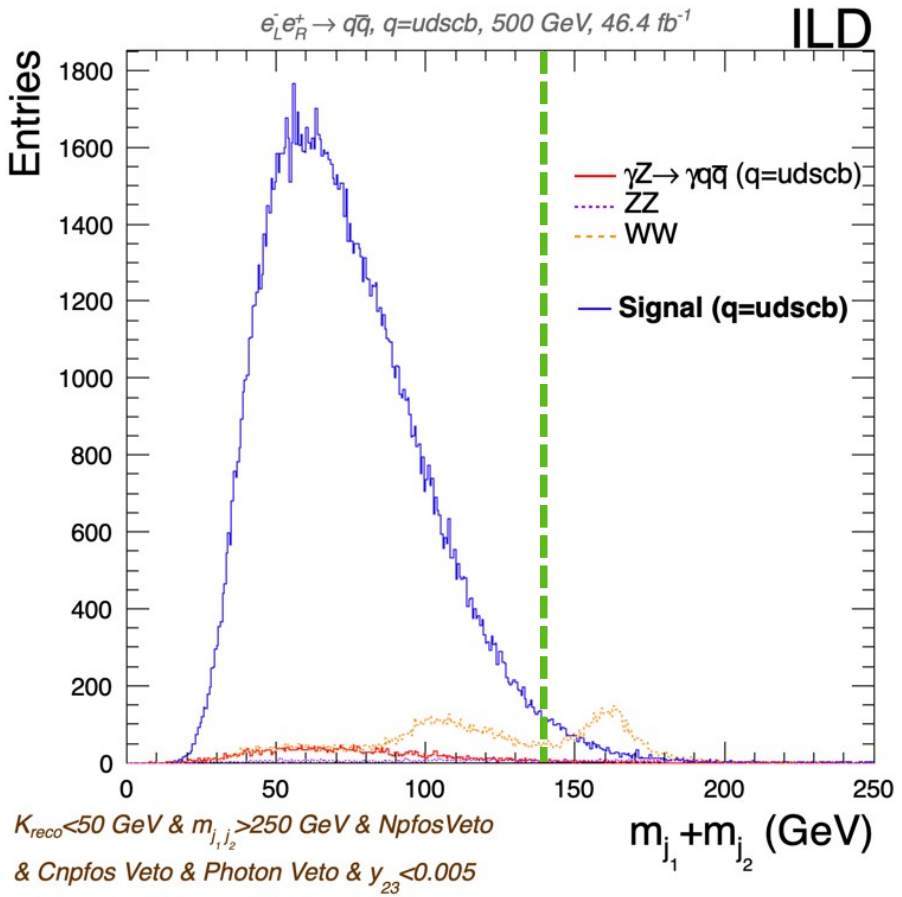


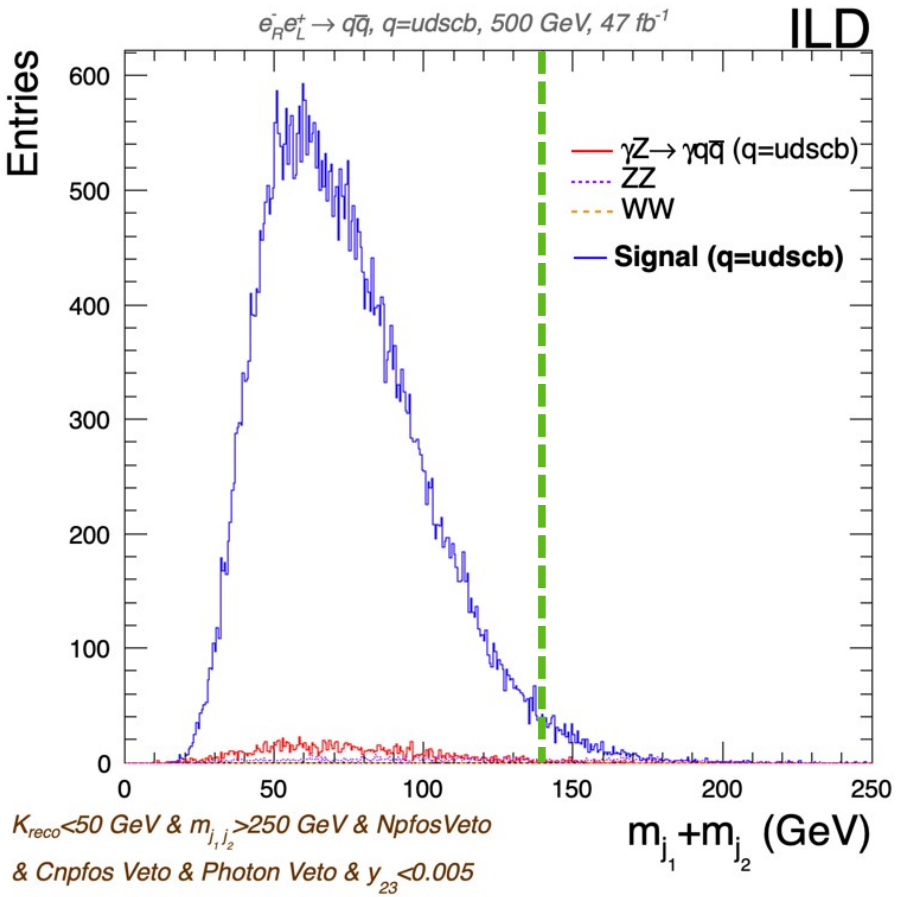
Sixth cut: $y_{23} < 0.005$





Seventh cut: $m_{j1}+m_{j2} < 140$ GeV





Final preselection ($e_L p_R$)

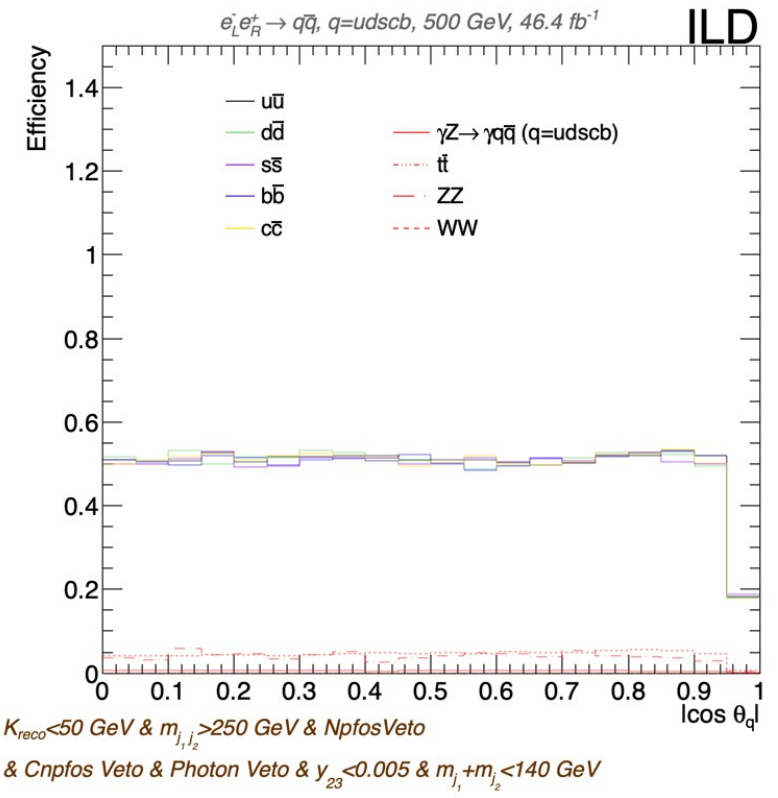
Cuts:

- K_{reco} < 50 GeV
- m_{2jets} > 250 GeV
- Charged N pfos > 0.5
- Neutral N pfos > 3.5
- Photon veto
- y_{23} < 0.005
- $m_{j1}+m_{j2}$ < 140 GeV

VLC Algorithm parameters:

- R = 1.0
- γ = 0.0
- β = 1.0

	Efficiency (%)			Background/Signal			
	$b\bar{b}$	$c\bar{c}$	$q\bar{q}$	ISR	WW	ZZ	$t\bar{t}$
No cut	100	100	100	3.50	1.06	0.09	0.10
+ Cut 1	74.9	74.7	74.7	0.76	0.77	0.06	0.01
+ Cut 2	74.8	74.6	74.7	0.74	0.77	0.06	9e-03
+ Cut 3	74.8	74.5	74.3	0.16	0.77	0.06	9e-03
+ Cut 4	74.7	74.5	74.1	0.11	0.77	0.06	9e-03
+ Cut 5	72.1	71.7	71.1	0.05	0.58	0.05	9e-03
+ Cut 6	49.6	49.7	49.6	0.03	0.09	0.01	1e-04
+ Cut 7	48.6	48.7	48.7	0.02	0.06	5e-03	5e-06



Final preselection ($e_R p_L$)

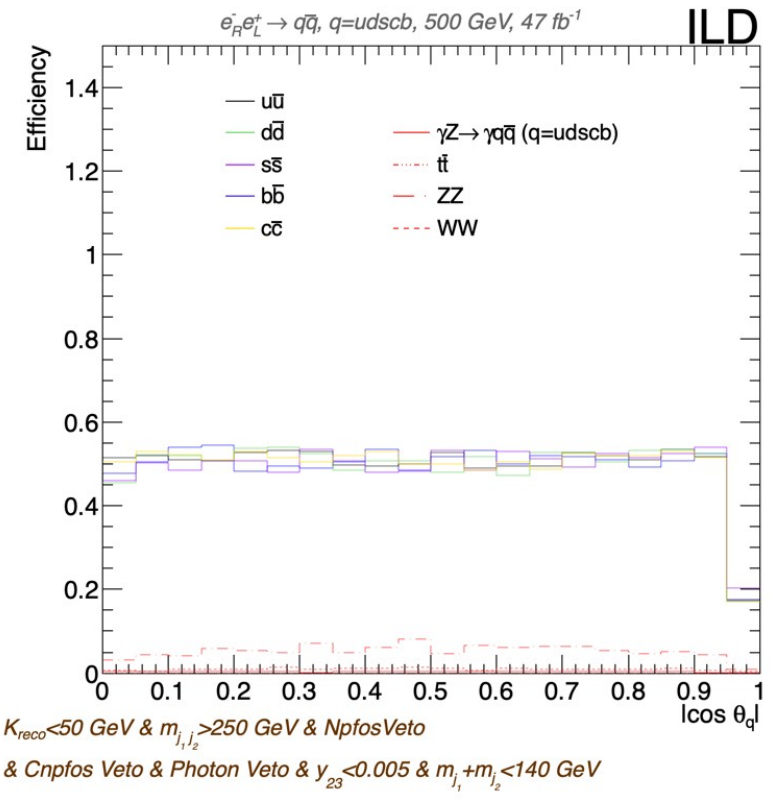
Cuts:

- K_{reco} < 50 GeV
- m_{2jets} > 250 GeV
- Charged N pfos > 0.5
- Neutral N pfos > 3.5
- Photon veto
- y_{23} < 0.005
- $m_{j1}+m_{j2}$ < 140 GeV (optional)

VLC Algorithm parameters:

- R = 1.0
- γ = 0.0
- β = 1.0

	Efficiency (%)			Background/Signal			
	$b\bar{b}$	$c\bar{c}$	$q\bar{q}$	ISR	WW	ZZ	$t\bar{t}$
No cut	100	100	100	6.51	0.01	0.11	0.10
+ Cut 1	74.6	74.6	75.0	1.45	0.01	0.07	0.01
+ Cut 2	74.5	74.5	75.0	1.43	0.01	0.07	0.01
+ Cut 3	74.5	74.4	74.7	0.26	0.01	0.07	0.01
+ Cut 4	74.5	74.4	74.5	0.18	0.01	0.07	0.01
+ Cut 5	71.9	71.7	71.5	0.07	0.01	0.06	0.01
+ Cut 6	49.5	49.6	49.6	0.03	5e-04	0.01	9e-05
+ Cut 7	48.5	48.8	58.7	0.03	3e-04	8e-03	3e-06

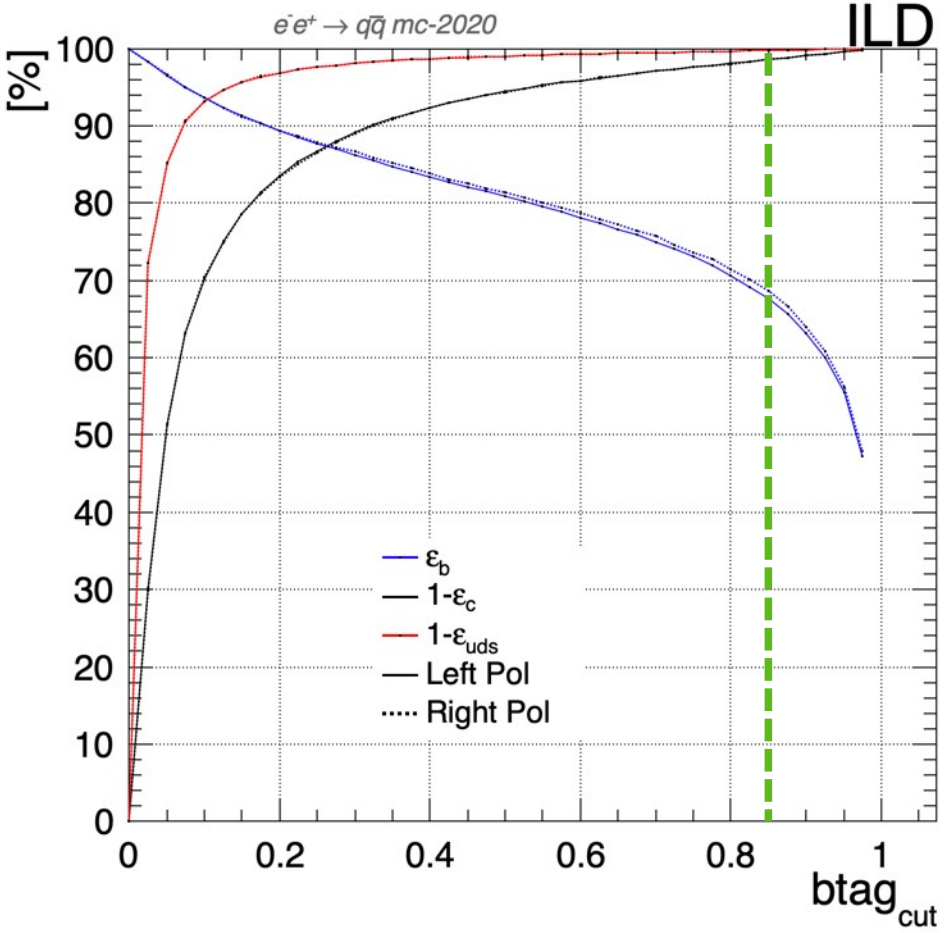


Next steps

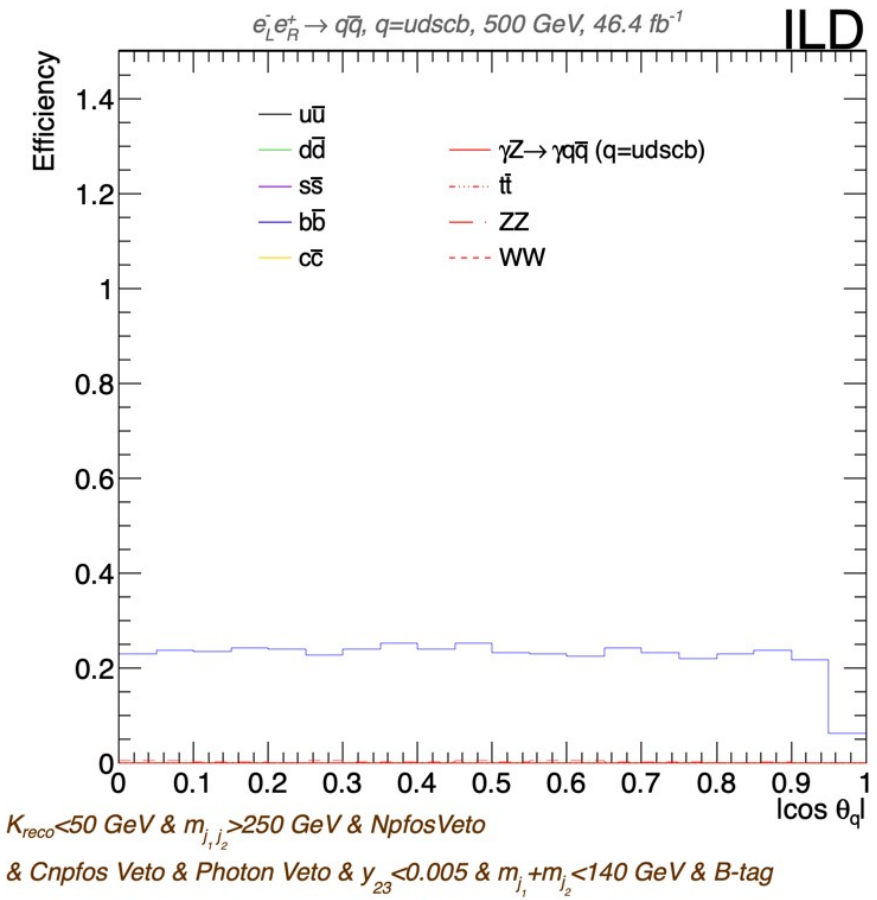
- We also checked the b-tag and c-tag setting used at 250 GeV and applied it to this 500 GeV samples (next 6 slides)

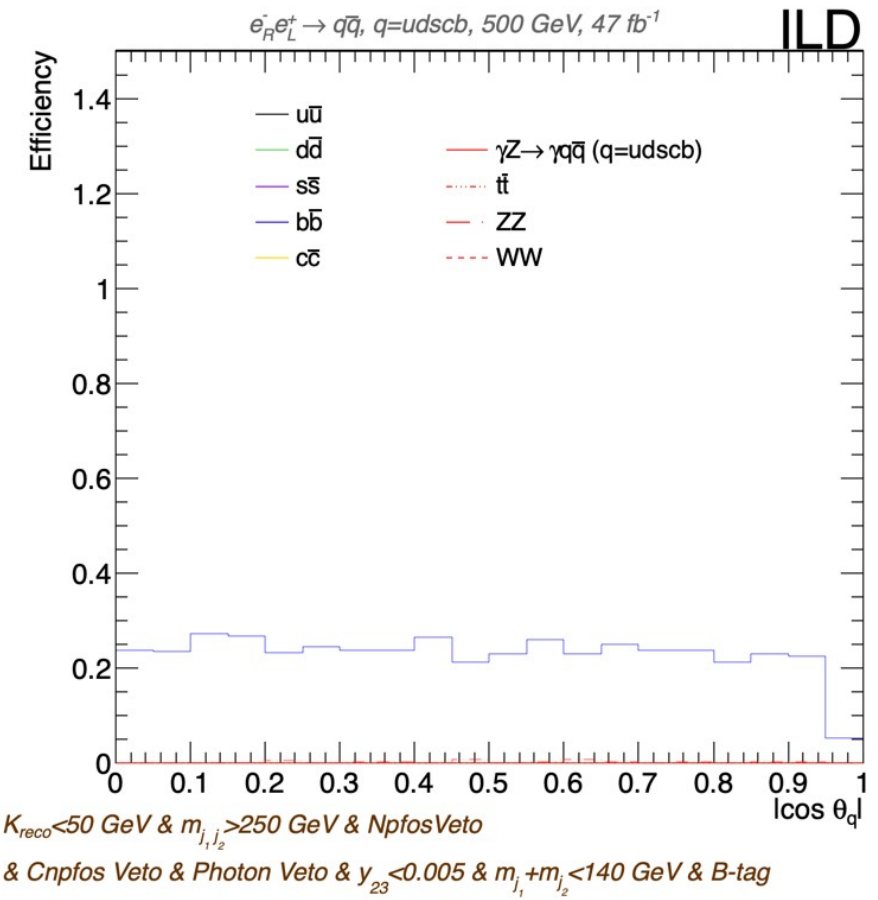
- We studied the dependence of the A_{FB} (at Monte-Carlo level) for different K_{ISR} values:
  - Last four slides: A_{FB} for b and c quarks signals (when $K<K_{ISR}$) in the center-of-momentum frame of reference. This shows that the cut in K_{reco} is safe.
  - Back-up: All plots including ISR (when $K>K_{ISR}$) in the lab and c.o.m. frames.
- Performing a re-training of the tagging and compare the performance
  - *To be done*

Cut in b-tag


$e^-e^+ \to q\bar{q}$ mc-2020
ILD
[%]
100
90
80
70
60
50
40
30
20
10
0
0
0.2
0.4
0.6
0.8
1
$btag_{cut}$
ε_b
$1-\varepsilon_c$
$1-\varepsilon_{uds}$
Left Pol
Right Pol

Cut in b-tag

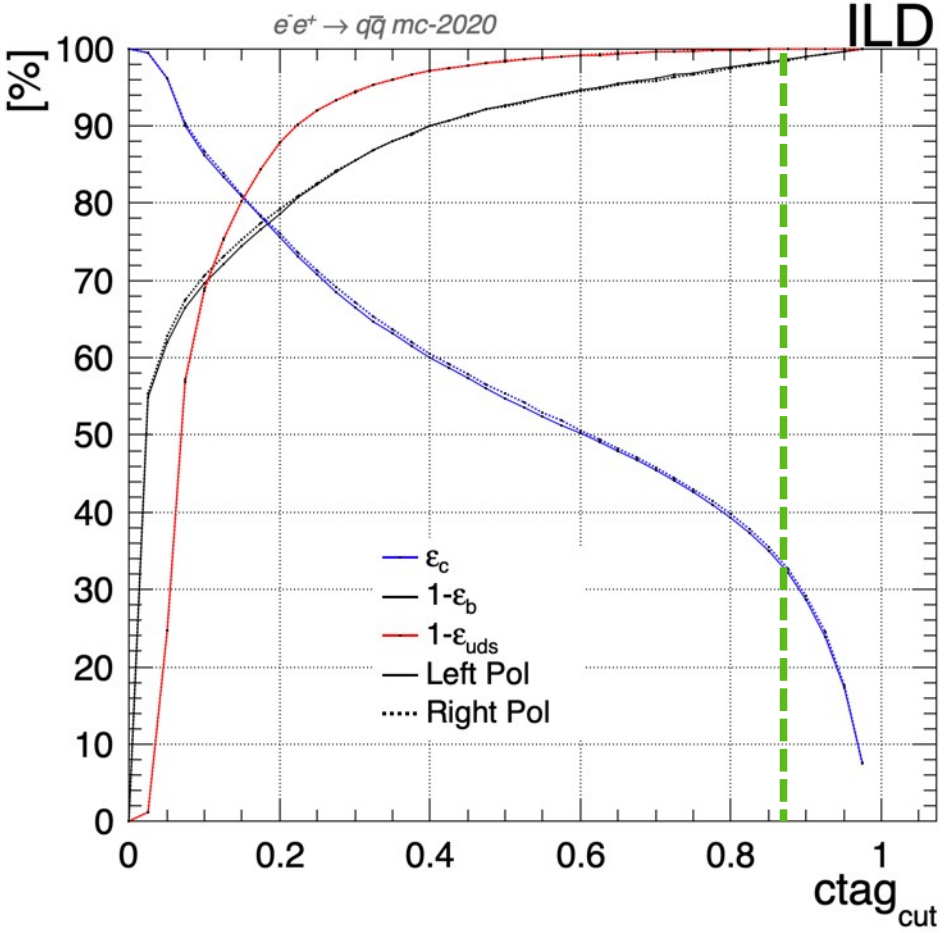

$e^-_L e^+_R \to q\bar{q}$, q=udscb, 500 GeV, 46.4 fb^{-1}
ILD
Efficiency
uū
dd̄
ss̄
bb̄
cc̄
γZ→ γqq̄ (q=udscb)
tt̄
ZZ
WW
|cos θ$_q$|
K_{reco}<50 GeV & $m_{j_1 j_2}$>250 GeV & NpfosVeto
& Cnpfos Veto & Photon Veto & y_{23}<0.005 & $m_{j_1}+m_{j_2}$<140 GeV & B-tag


$e^-_R e^+_L \to q\bar{q}$, q=udscb, 500 GeV, 47 fb^{-1}
ILD
Efficiency
uū
dd̄
ss̄
bb̄
cc̄
γZ→ γqq̄ (q=udscb)
tt̄
ZZ
WW
|cos θ$_q$|
K_{reco}<50 GeV & $m_{j_1 j_2}$>250 GeV & NpfosVeto
& Cnpfos Veto & Photon Veto & y_{23}<0.005 & $m_{j_1}+m_{j_2}$<140 GeV & B-tag

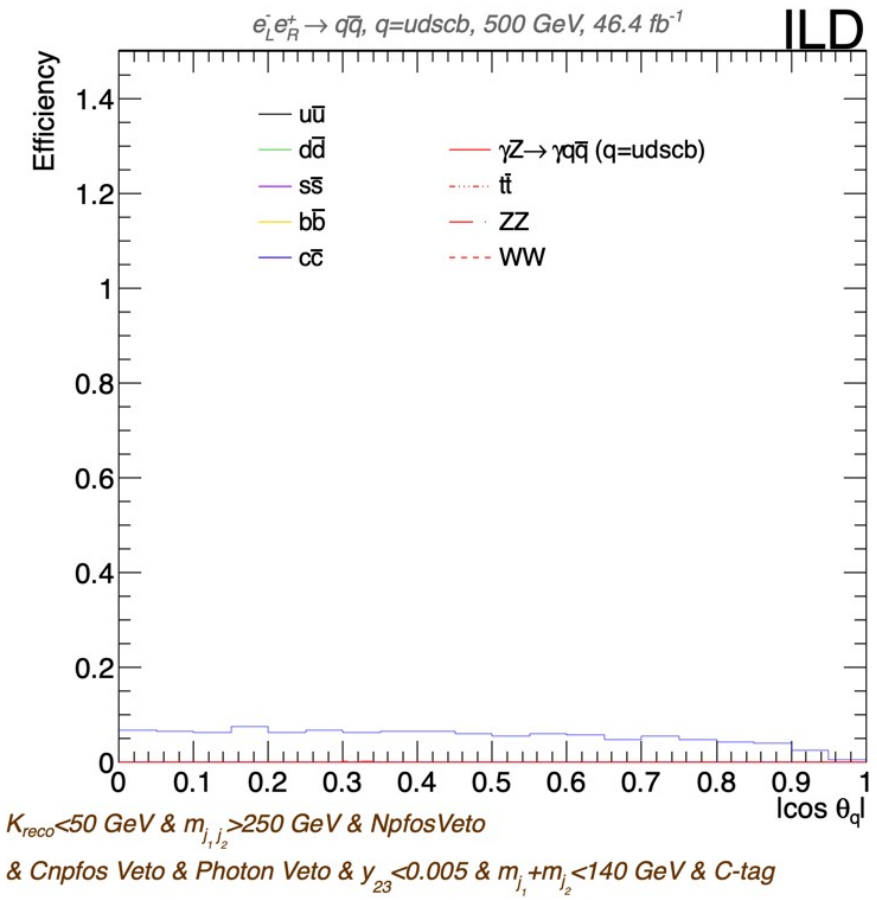
Cut in b-tag

	Efficiency (%)			Background/Signal			
	$b\bar{b}$	$c\bar{c}$	$q\bar{q}$	ISR	WW	ZZ	$t\bar{t}$
$e_L p_R$	22.1	0.01	0	0.02	8e-05	3e-03	6e-06
$e_R p_L$	22.4	0.01	2e-03	0.02	0	6e-03	0

Cut in c-tag


$e^-e^+ \to q\bar{q}$ mc-2020
ILD
[%]
100
90
80
70
60
50
40
30
20
10
0
0
0.2
0.4
0.6
0.8
1
$ctag_{cut}$
ε_c
$1-\varepsilon_b$
$1-\varepsilon_{uds}$
Left Pol
Right Pol

Cut in c-tag


$e^-_L e^+_R \to q\bar{q}$, q=udscb, 500 GeV, 46.4 fb^{-1}
ILD
Efficiency
uū
dd̄
ss̄
bb̄
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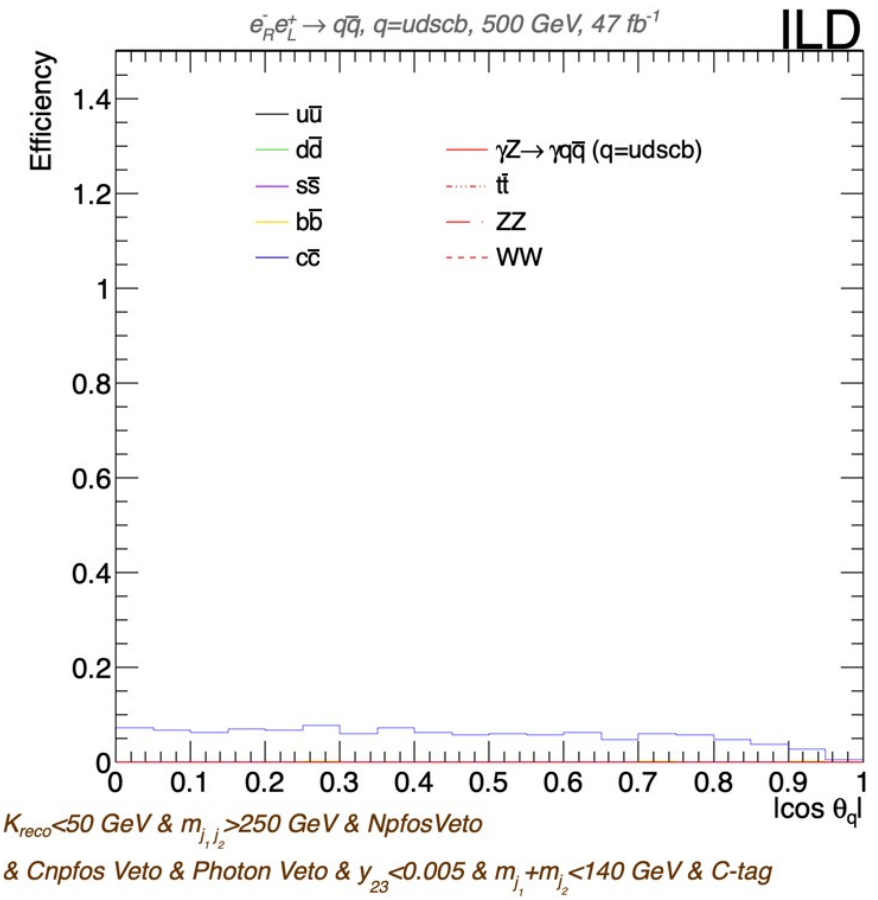
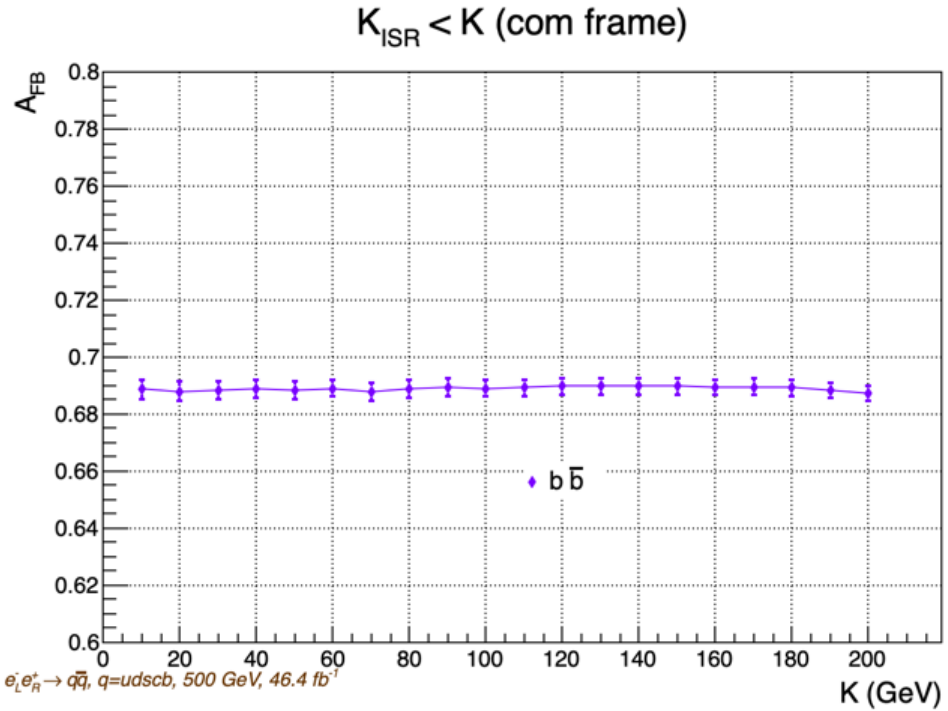
γZ→ γqq̄ (q=udscb)
tt̄
ZZ
WW
|cos θq|
K_{reco}<50 GeV & $m_{j_1 j_2}$>250 GeV & NpfosVeto
& Cnpfos Veto & Photon Veto & y_{23}<0.005 & $m_{j_1}+m_{j_2}$<140 GeV & C-tag

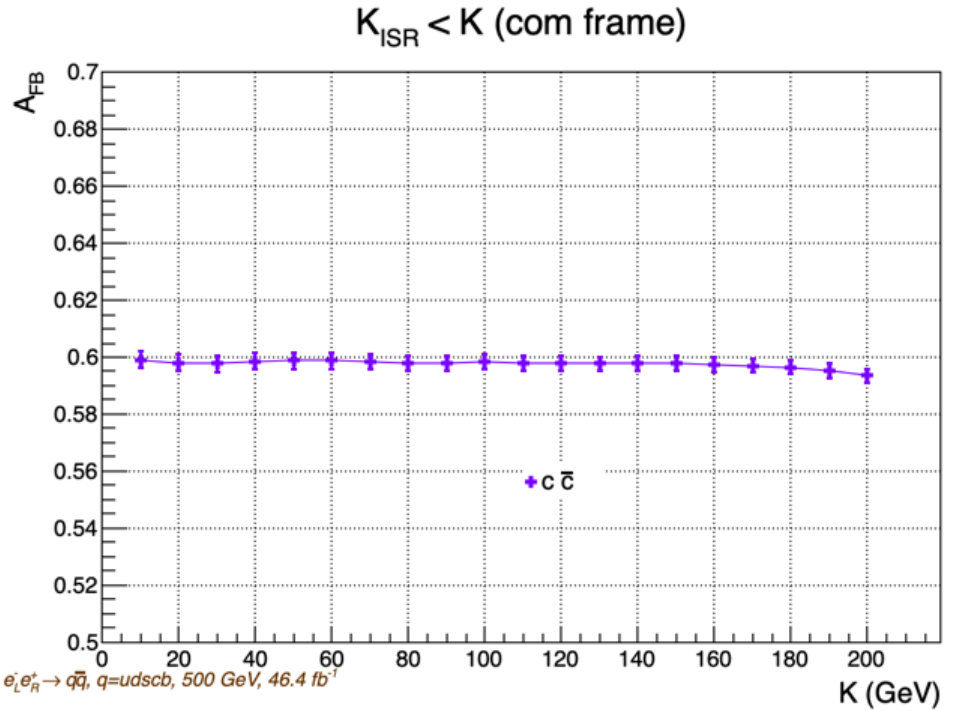

$e^-_R e^+_L \to q\bar{q}$, q=udscb, 500 GeV, 47 fb^{-1}
ILD
Efficiency
uū
dd̄
ss̄
bb̄
cc̄
γZ→ γqq̄ (q=udscb)
tt̄
ZZ
WW
|cos θq|
K_{reco}<50 GeV & $m_{j_1 j_2}$>250 GeV & NpfosVeto
& Cnpfos Veto & Photon Veto & y_{23}<0.005 & $m_{j_1}+m_{j_2}$<140 GeV & C-tag

Cut in c-tag

	Efficiency (%)			Background/Signal			
	$b\bar{b}$	$c\bar{c}$	$q\bar{q}$	ISR	WW	ZZ	$t\bar{t}$
$e_L p_R$	0.01	5.0	0	0.02	2e-04	6e-04	0
$e_R p_L$	0.03	5.3	0	0.02	0	3e-04	0

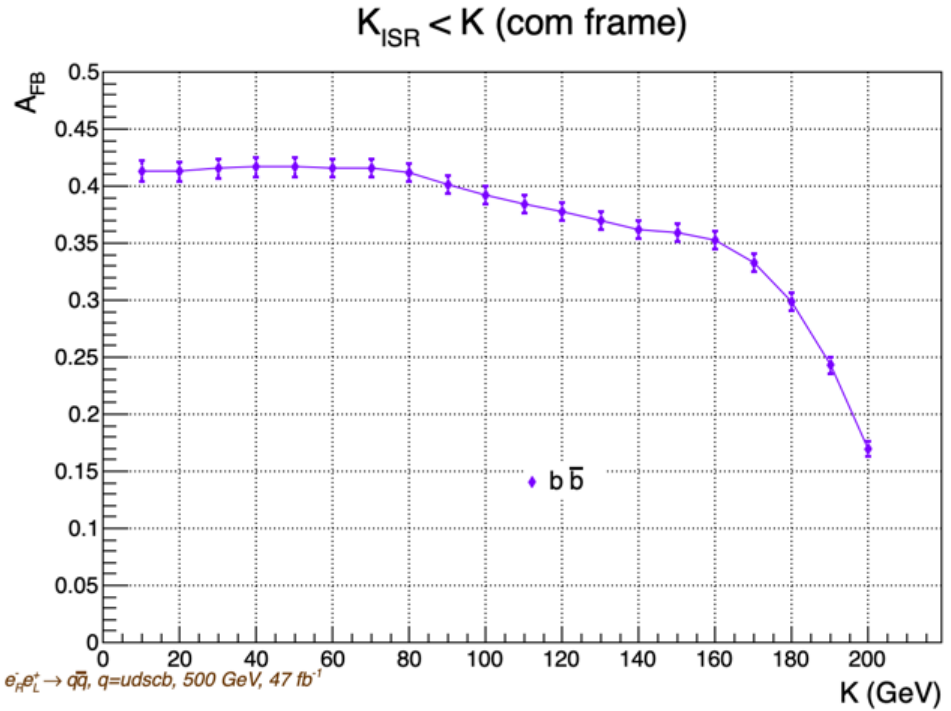
Zoom in K_{ISR} ($e_L p_R$)

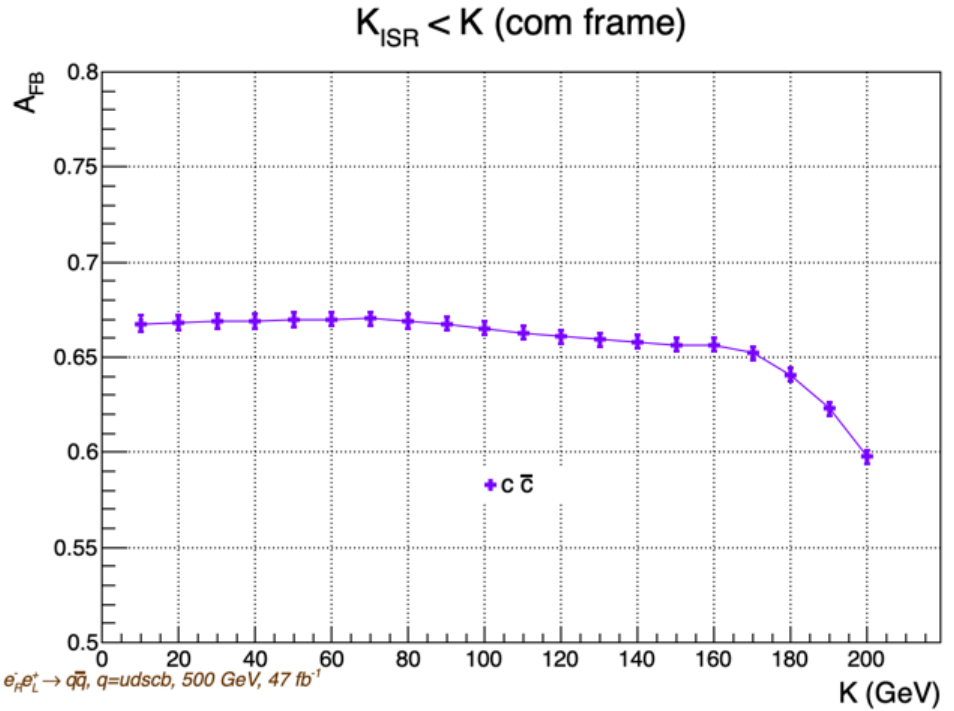




Zoom in K_{ISR} ($e_R p_L$)

The signals change drastically when K_{ISR}>80 GeV





Back-Up slides

Samples (500 GeV)

$e_L p_R$

Luminosity (fb^{-1})			
$q\bar{q}$ + ISR	WW	ZZ	$t\bar{t}_1$
46.4	49.0	56.6	7704.9

Cross-Section (fb)			
$q\bar{q}$ + ISR	WW	ZZ	$t\bar{t}_1$
32470.5	7680	680.2	165.0

K_{ISR}<20 GeV

	Cross-Section (fb)				
	$b\bar{b}$	$c\bar{c}$	$s\bar{s}$	$u\bar{u}$	$d\bar{d}$
$q\bar{q}$	1051.6	1633.1	1051.5	1643.5	1058.2
ISR	5391.9	4933.3	5389.0	4951.9	5366.6
Ratio	5.1	3	5.1	3	5.1

K_{ISR}<70 GeV

	Cross-Section (fb)				
	$b\bar{b}$	$c\bar{c}$	$s\bar{s}$	$u\bar{u}$	$d\bar{d}$
$q\bar{q}$	1231.3	1917.3	1232.2	1923.5	1239.9
ISR	5212.2	4649.1	5208.4	4671.8	5184.9
Ratio	4.2	2.4	4.2	2.4	4.2

$e_R p_L$

Luminosity (fb^{-1})			
$q\bar{q}$ + ISR	WW	ZZ	$t\bar{t}_1$
47.0	500	72.5	8354.1

Cross-Section (fb)			
$q\bar{q}$ + ISR	WW	ZZ	$t\bar{t}_1$
17994.7	33.5	271.9	63.7

K_{ISR}<20 GeV

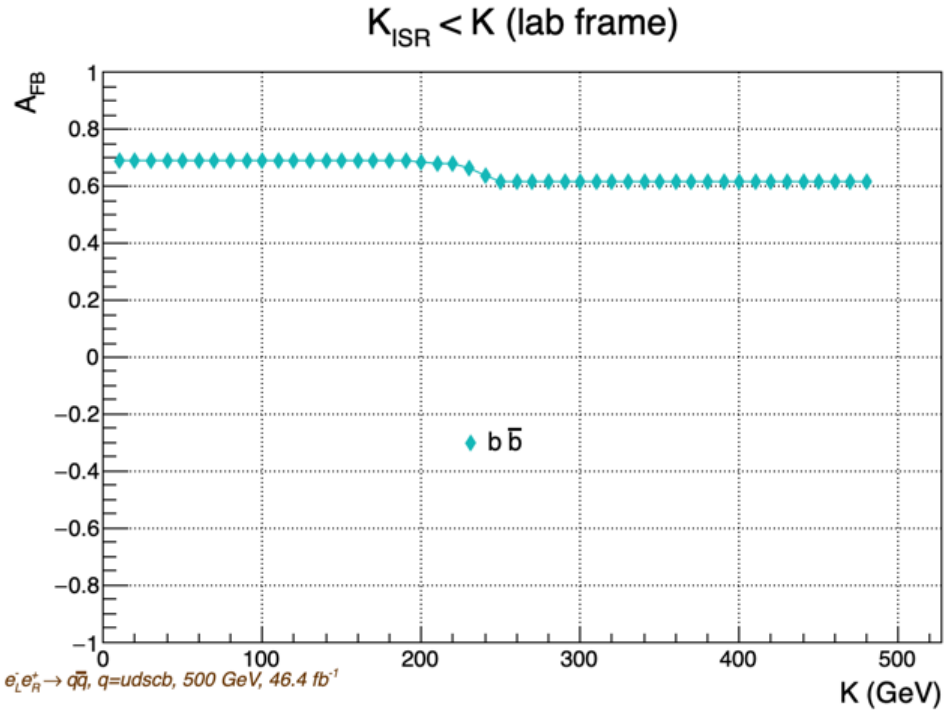
	Cross-Section (fb)				
	$b\bar{b}$	$c\bar{c}$	$s\bar{s}$	$u\bar{u}$	$d\bar{d}$
$q\bar{q}$	226.6	733.0	221.7	732.8	224.1
ISR	3233.5	3092.5	3222.5	3075.0	3243
Ratio	14.2	4.2	14.5	4.2	14.5

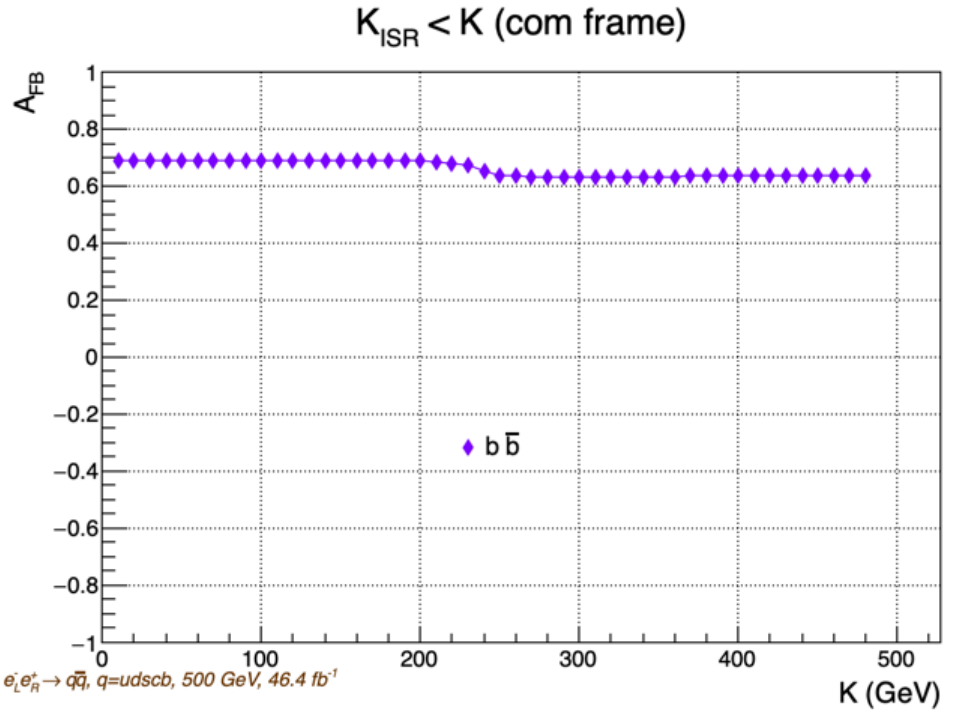
K_{ISR}<70 GeV

	Cross-Section (fb)				
	$b\bar{b}$	$c\bar{c}$	$s\bar{s}$	$u\bar{u}$	$d\bar{d}$
$q\bar{q}$	264.7	857.9	260.1	857.5	263.7
ISR	3185.4	2967.7	3184.1	2950.3	3203.5
Ratio	12.0	3.5	12.2	3.4	12.1

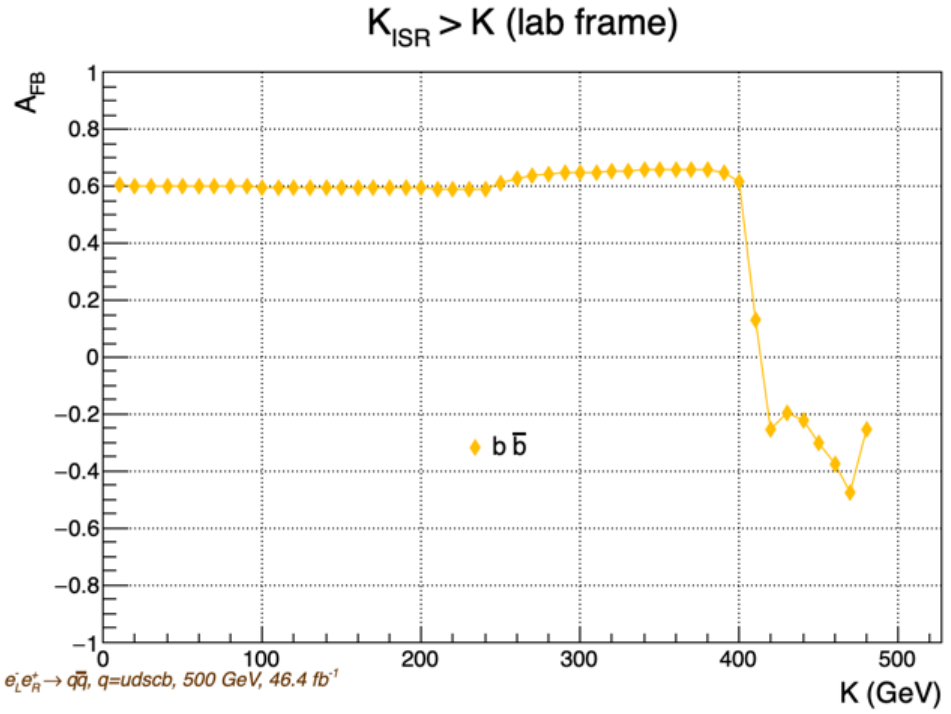
1: There are 4 different samples (for different processes), this is the average numbers for each of them

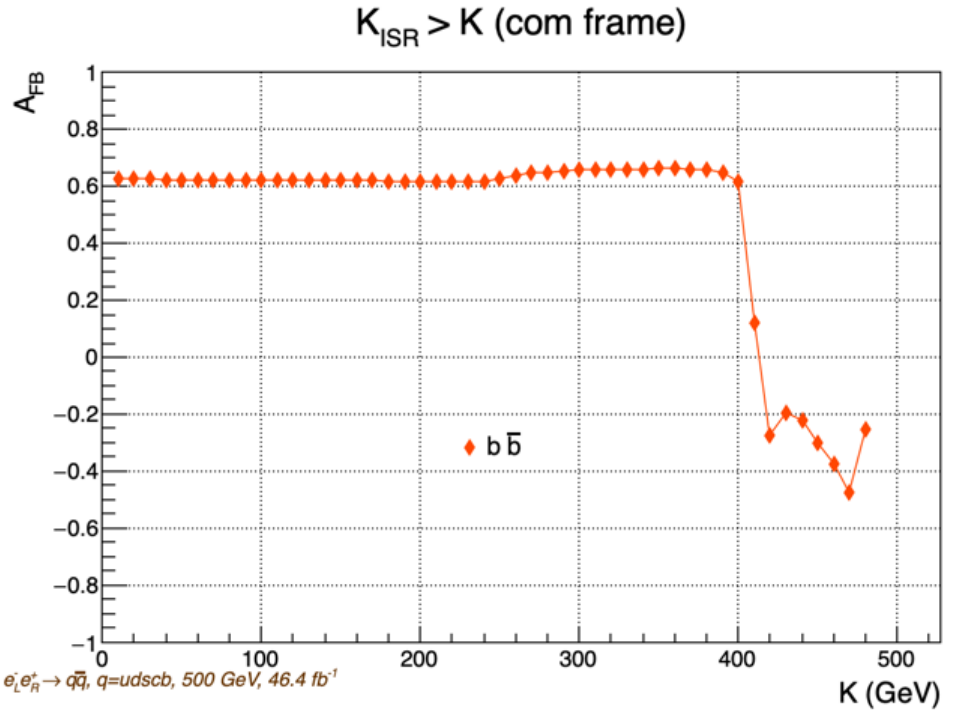
A_{FB} value for different K_{ISR} ($e_L p_R$)



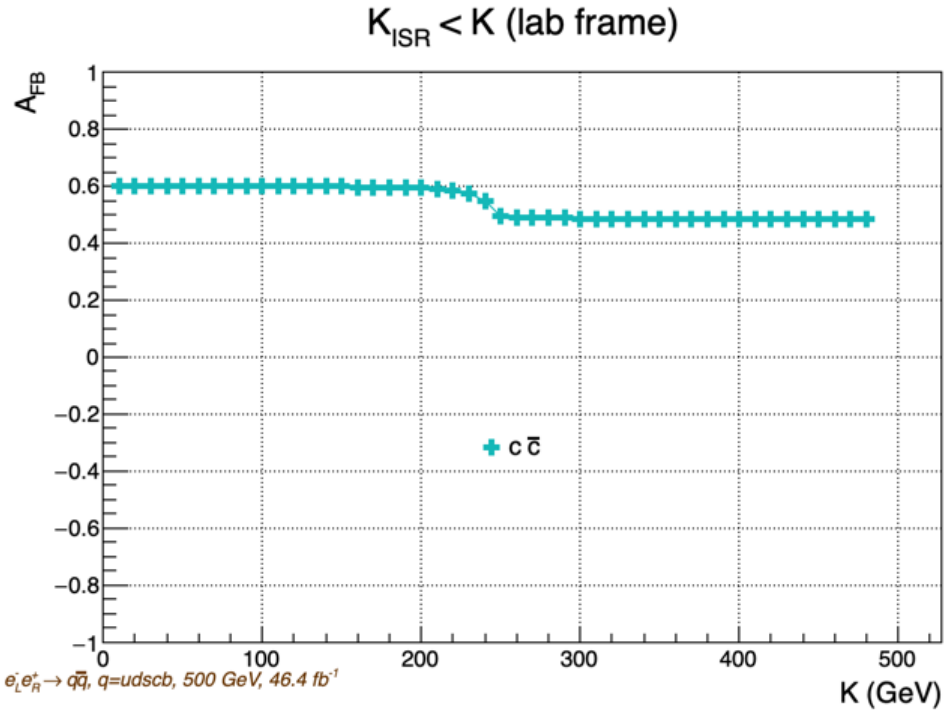


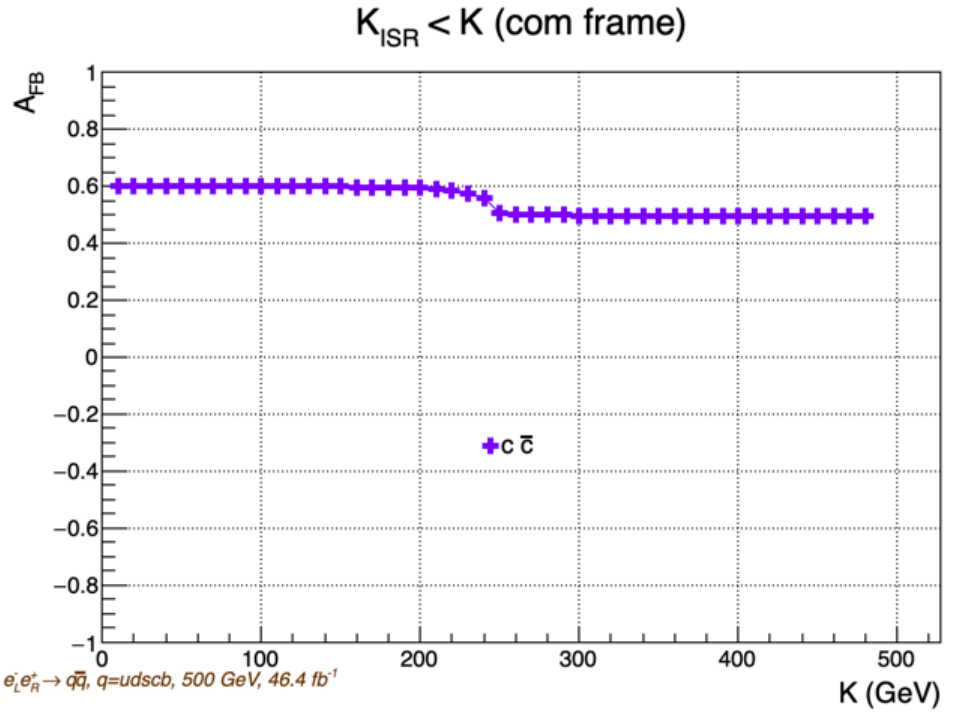
A_{FB} value for different K_{ISR} ($e_L p_R$)



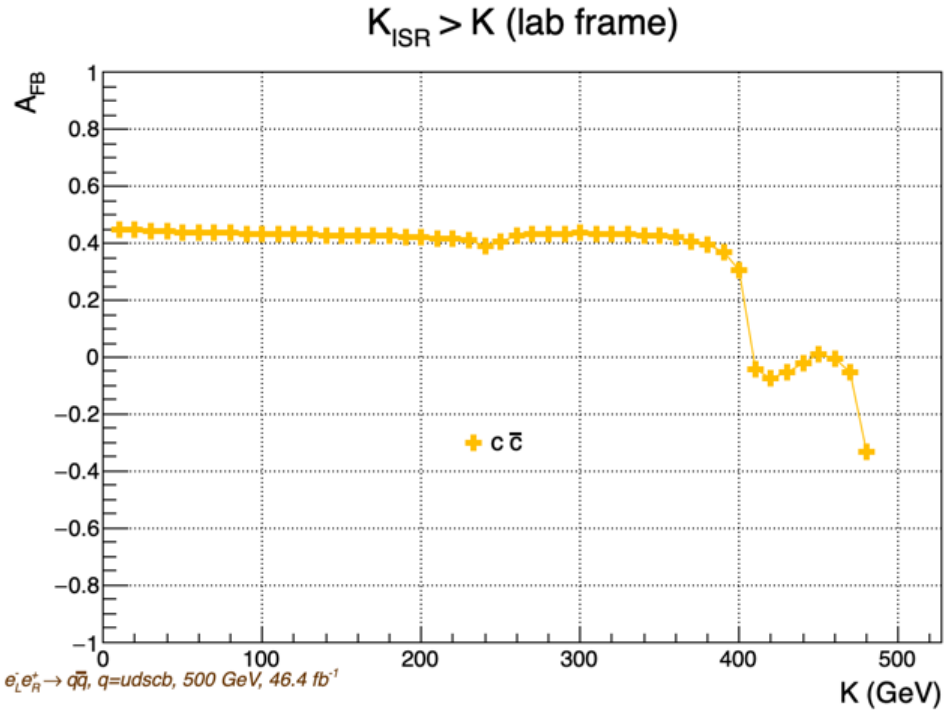


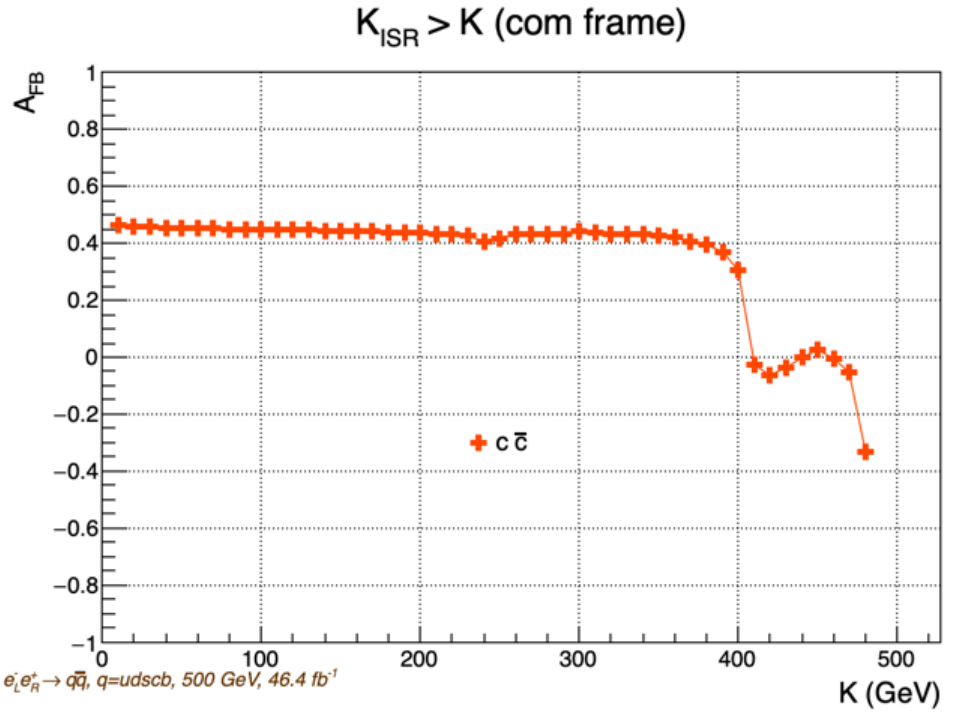
A_{FB} value for different K_{ISR} ($e_L p_R$)



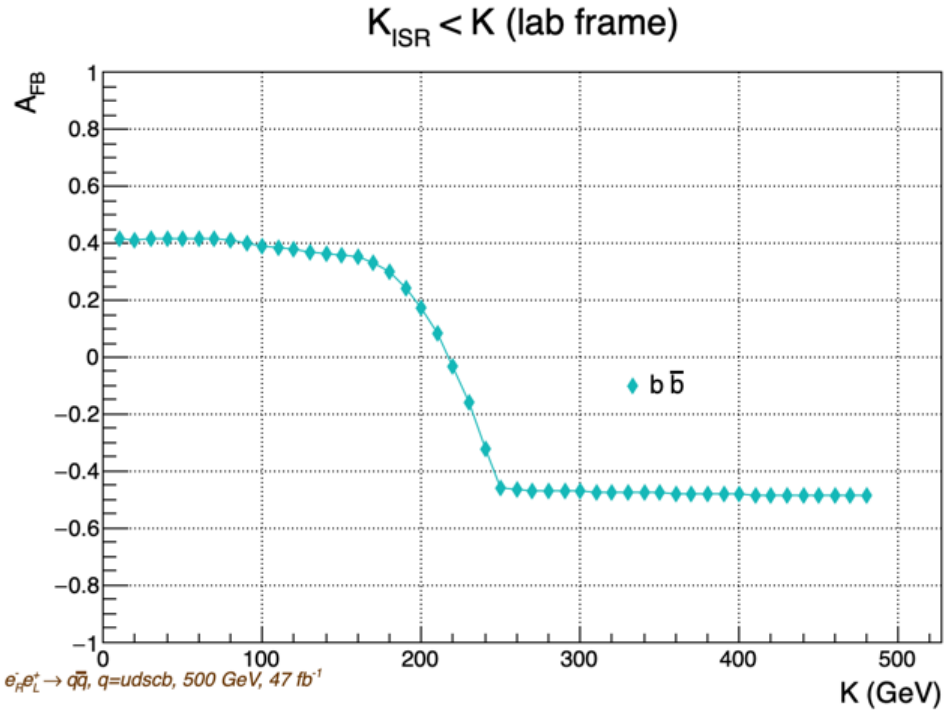


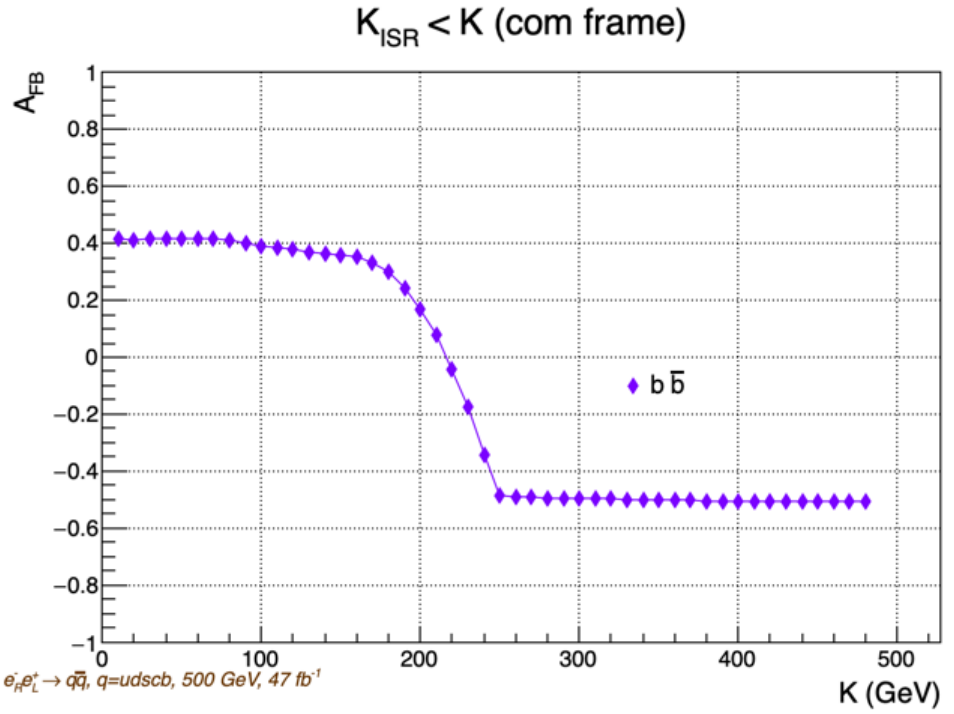
A_{FB} value for different K_{ISR} ($e_L p_R$)



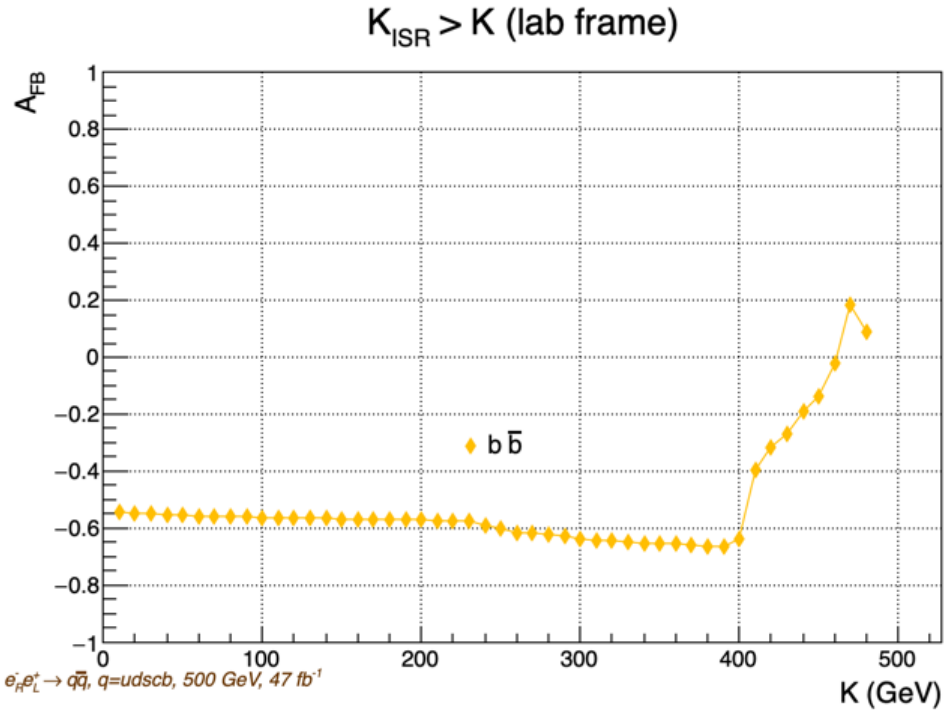


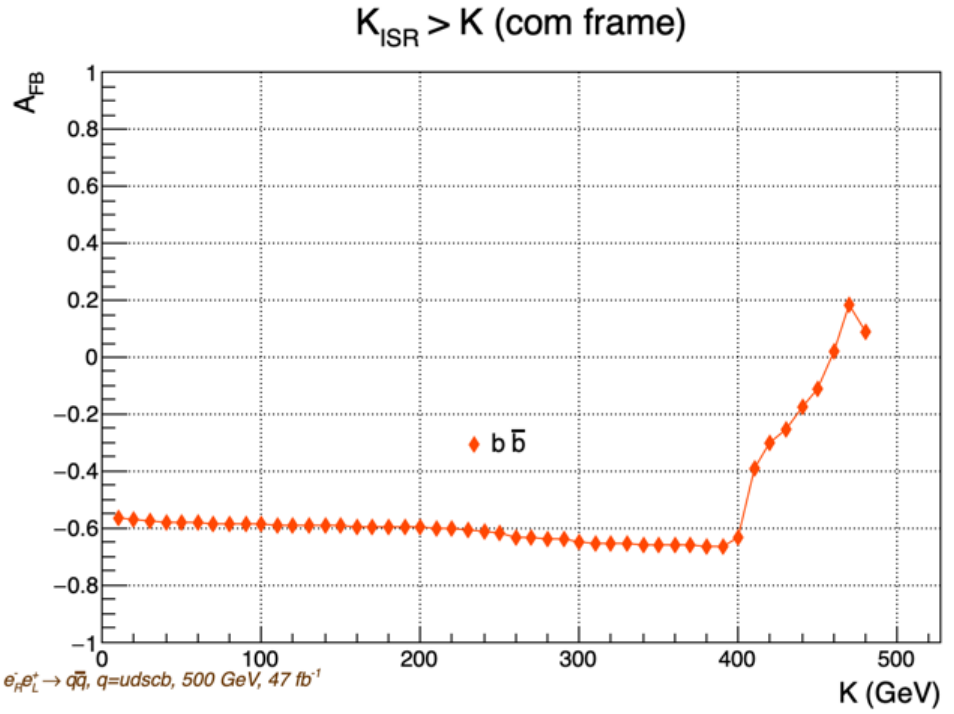
A_{FB} value for different K_{ISR} ($e_R p_L$)



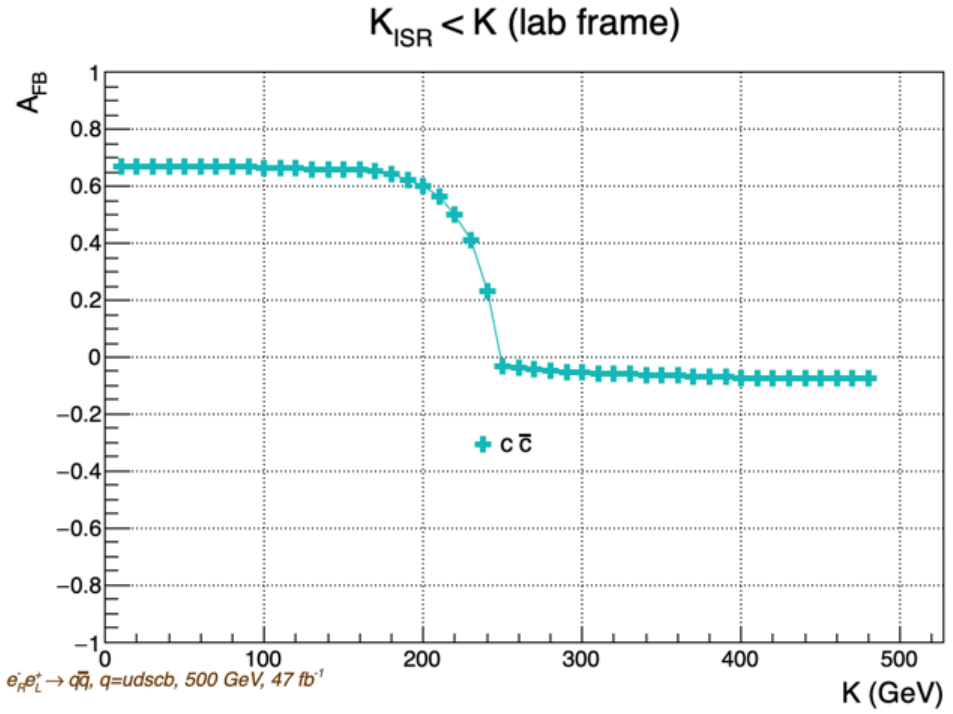


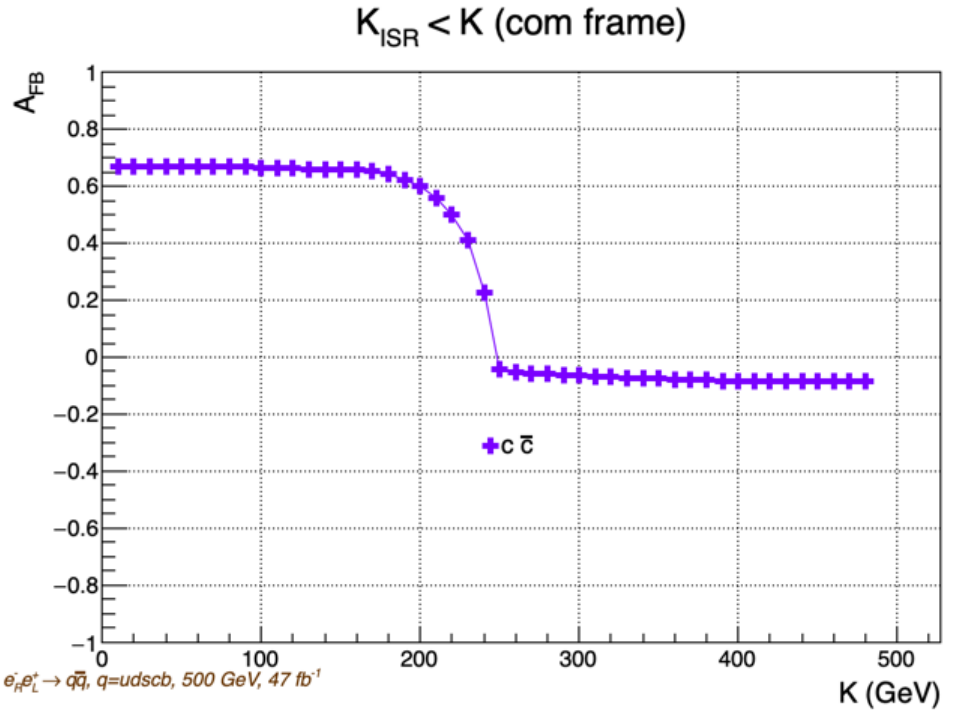
A_{FB} value for different K_{ISR} ($e_R p_L$)



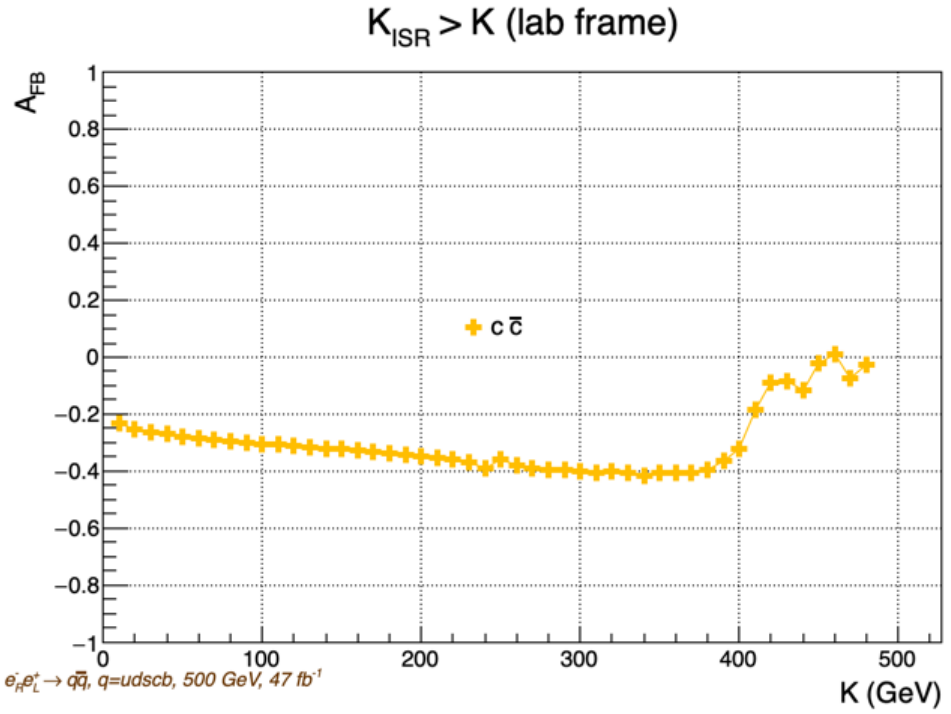


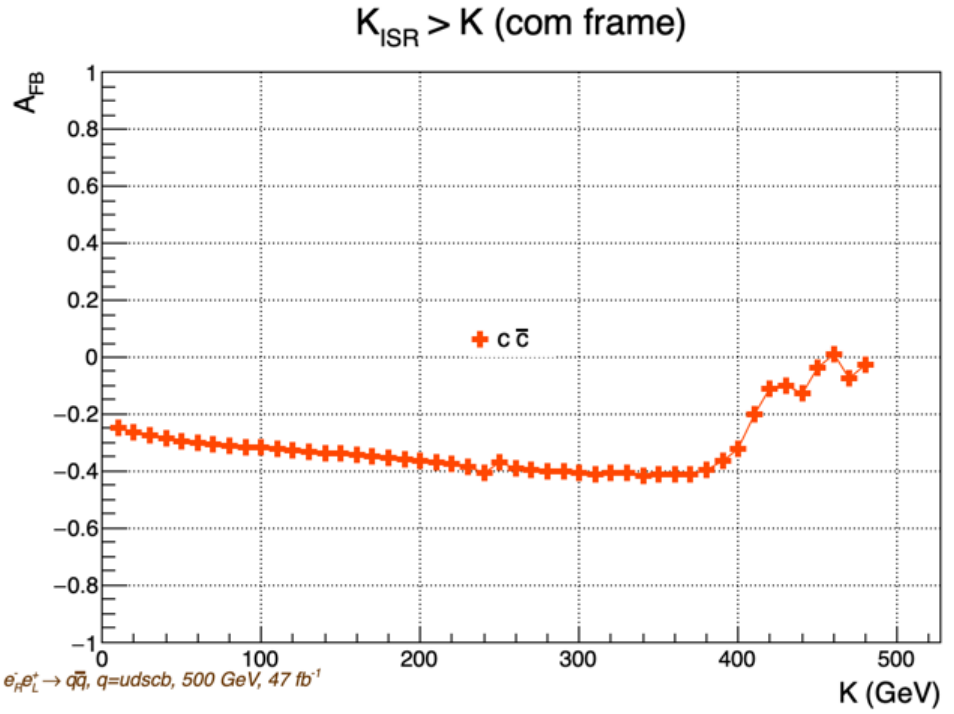
A_{FB} value for different K_{ISR} ($e_R p_L$)



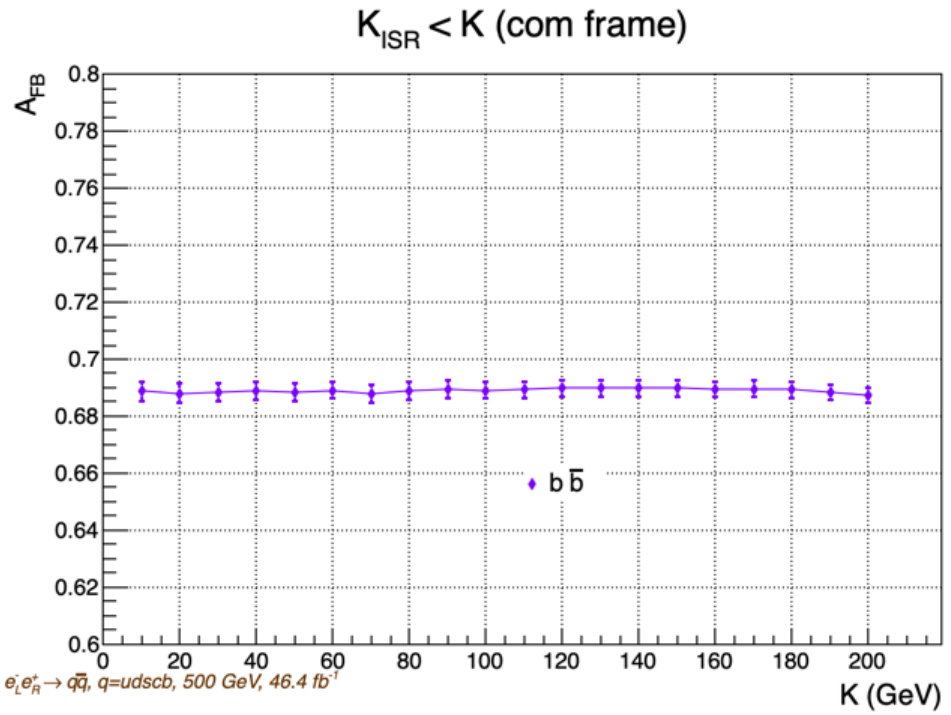


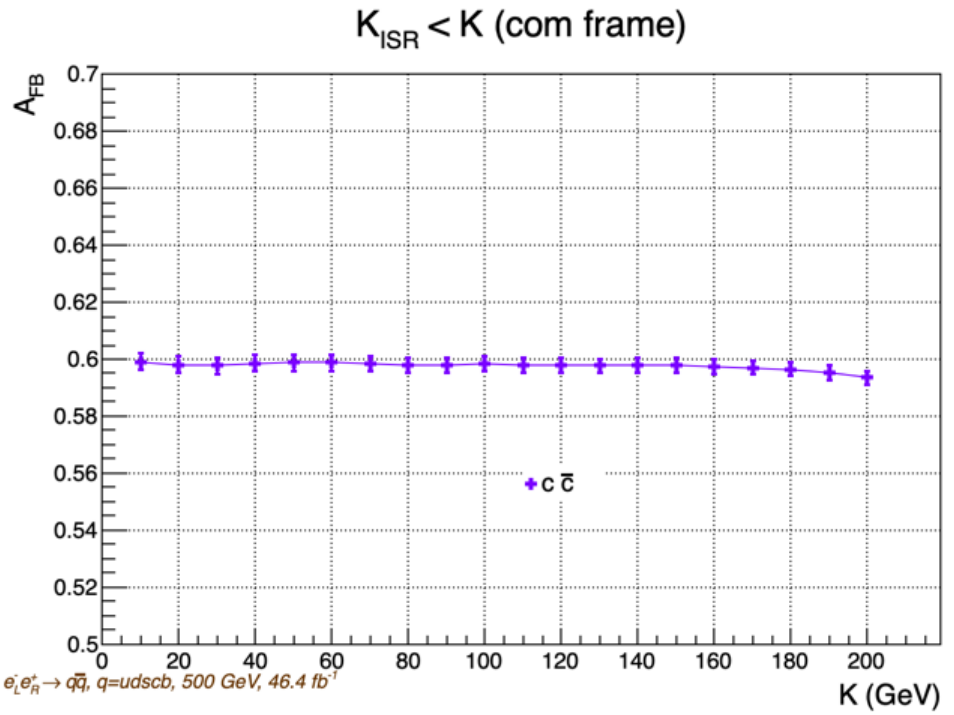
A_{FB} value for different K_{ISR} ($e_R p_L$)





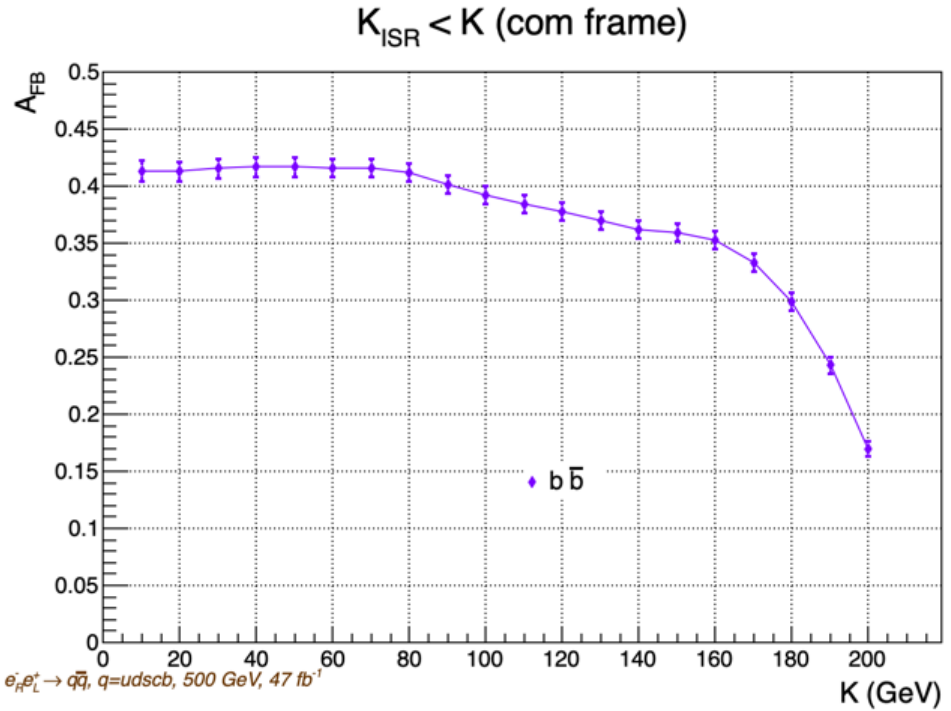
Zoom in K_{ISR} ($e_L p_R$)

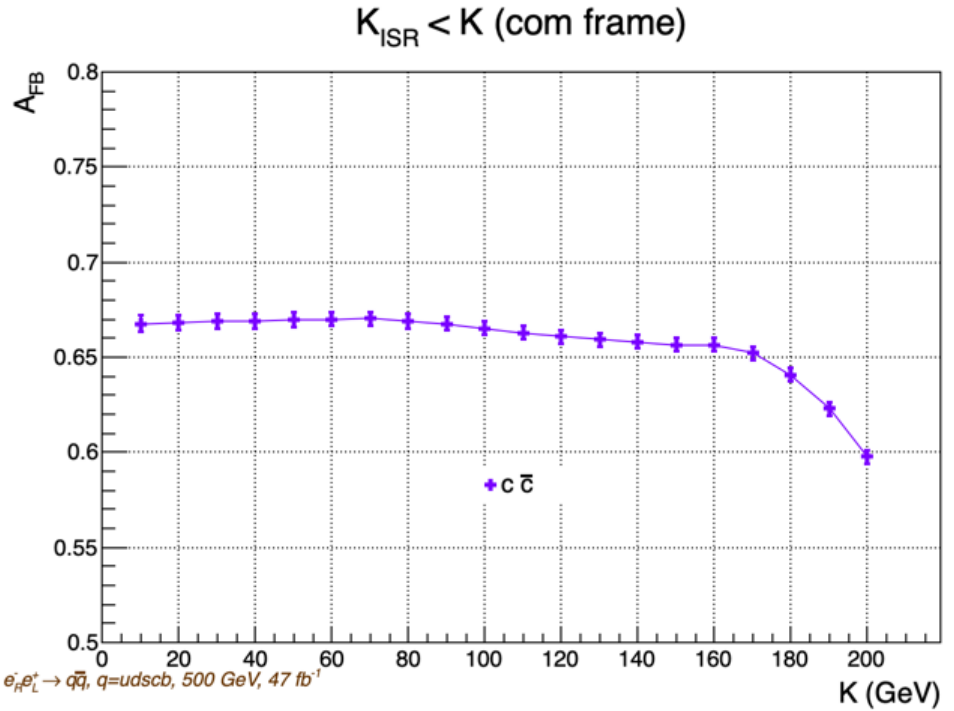




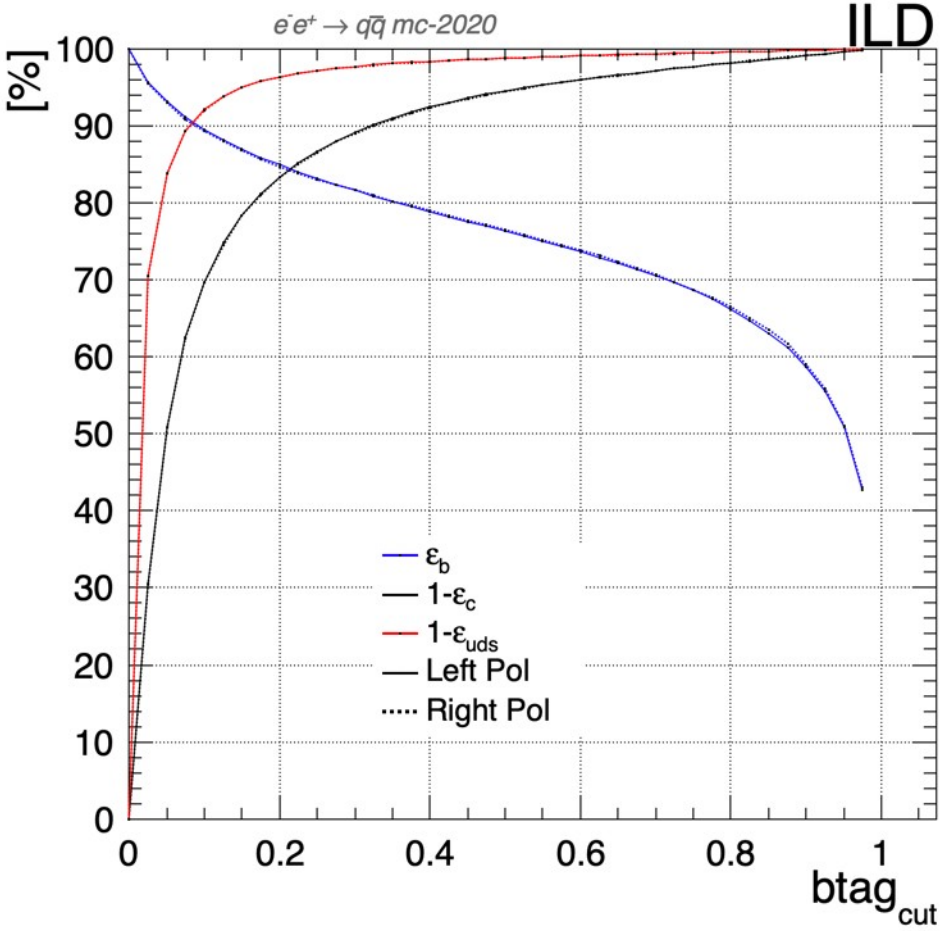
Zoom in K_{ISR} ($e_R p_L$)

The signals change drastically when K_{ISR}>80 GeV





b-tag – Cut 0


ILD
$e^-e^+ \rightarrow q\bar{q}$ mc-2020
[%]
100
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0.4
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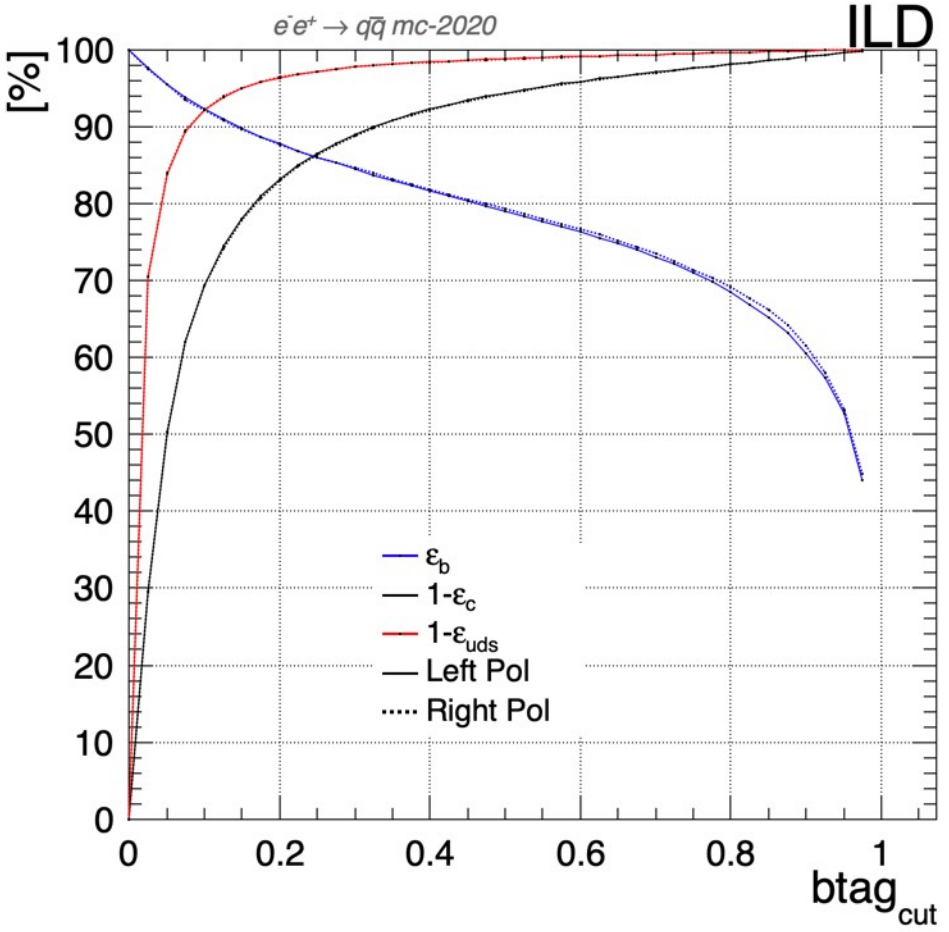
0.8
1
$btag_{cut}$
ε_b
$1-\varepsilon_c$
$1-\varepsilon_{uds}$
Left Pol
Right Pol

b-tag – Cut 1


ILD
$e^-e^+ \rightarrow q\bar{q}$ mc-2020
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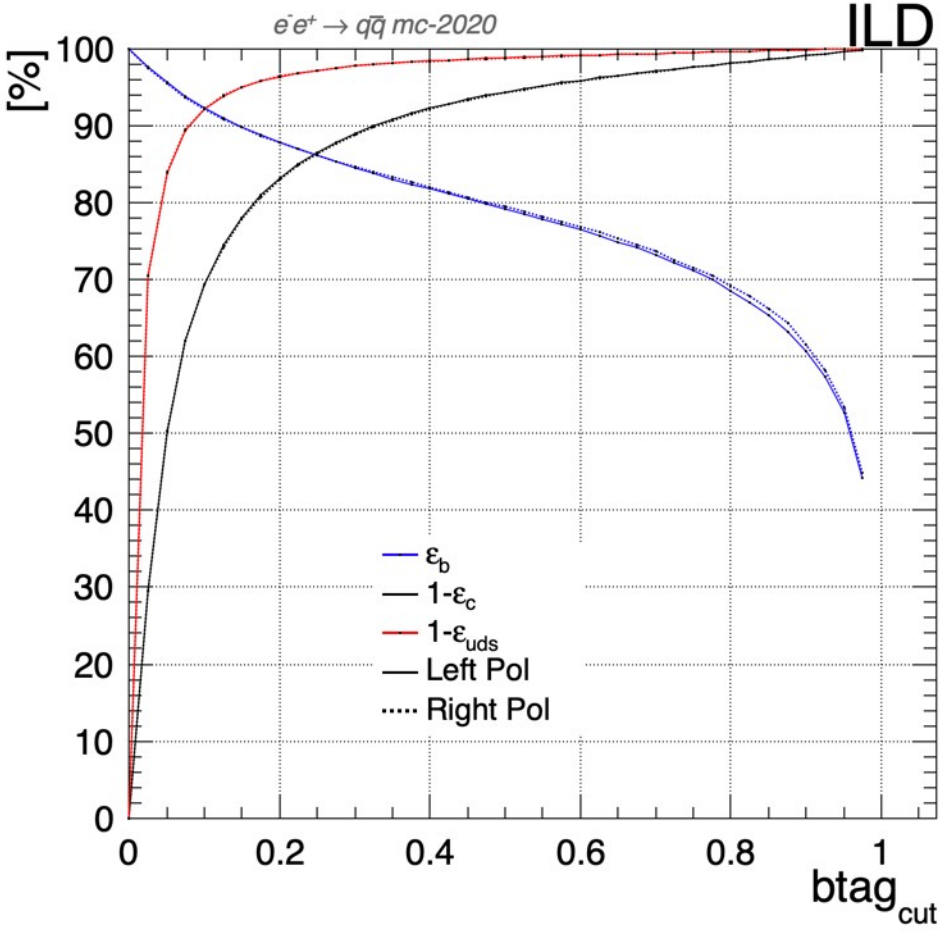
1
$btag_{cut}$
ε_b
$1-\varepsilon_c$
$1-\varepsilon_{uds}$
Left Pol
Right Pol

b-tag – Cut 2


ILD
$e^-e^+ \rightarrow q\bar{q}$ mc-2020
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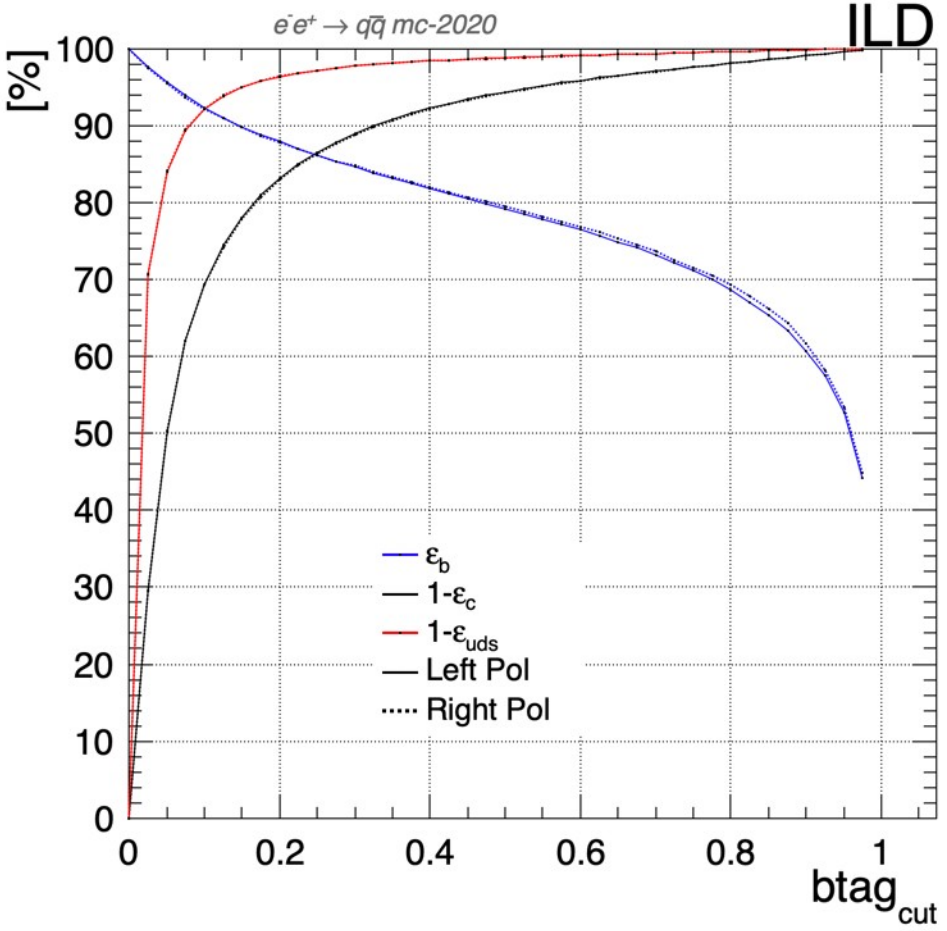
$btag_{cut}$
ε_b
$1-\varepsilon_c$
$1-\varepsilon_{uds}$
Left Pol
Right Pol

b-tag – Cut 3


$e^-e^+ \to q\bar{q}$ mc-2020
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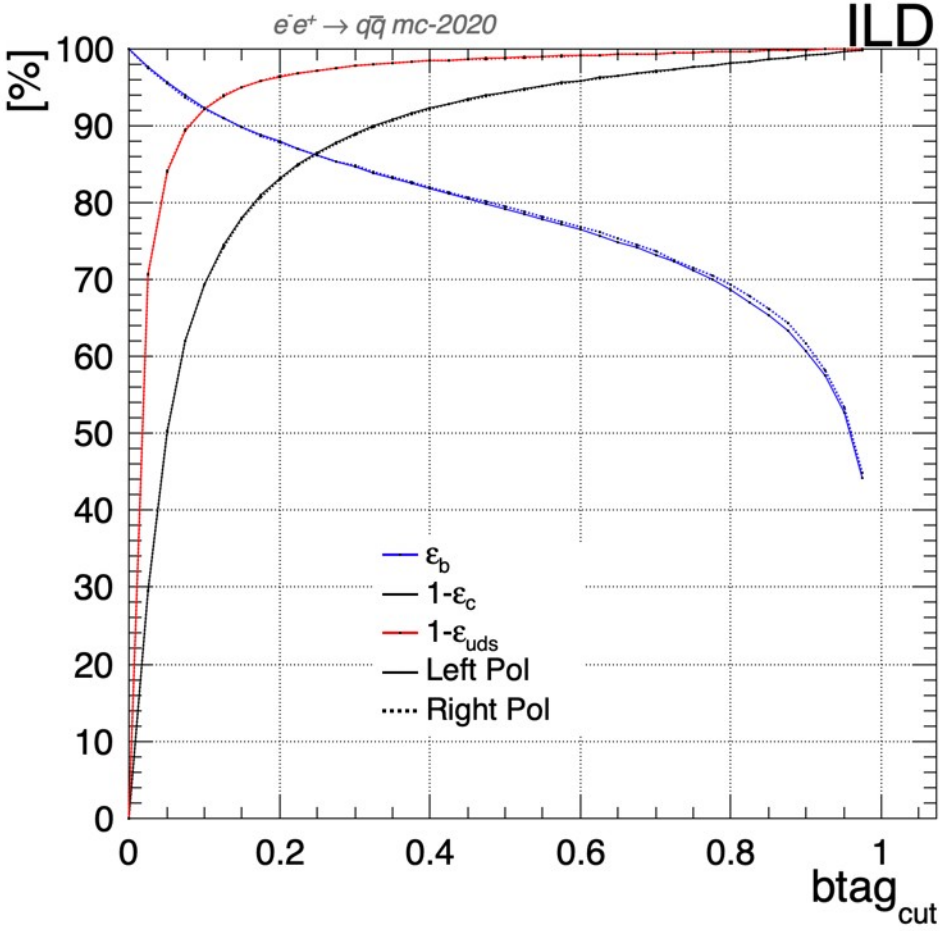
0.8
1
btag$_{cut}$
ε_b
1-ε_c
1-ε_{uds}
Left Pol
Right Pol

b-tag – Cut 4


ILD
$e^-e^+ \rightarrow q\bar{q}$ mc-2020
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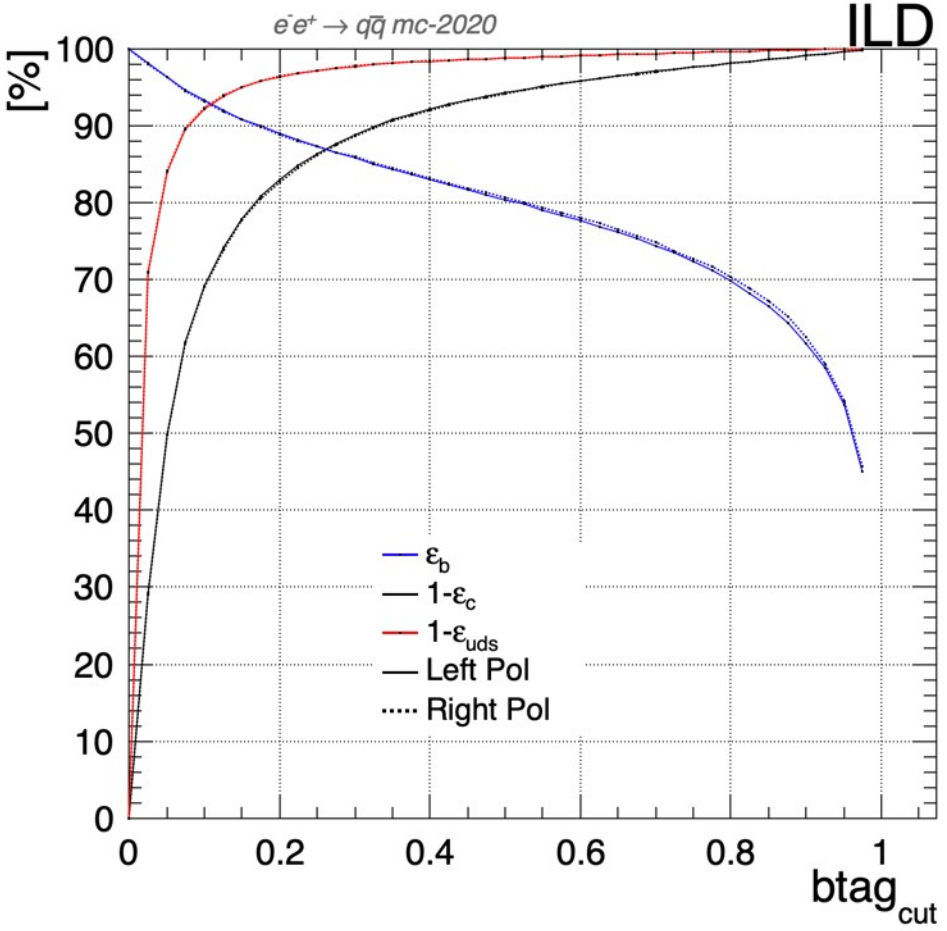
btag$_{cut}$
ε_b
1-ε_c
1-ε_{uds}
Left Pol
Right Pol

b-tag – Cut 5


$e^-e^+ \to q\bar{q}$ mc-2020
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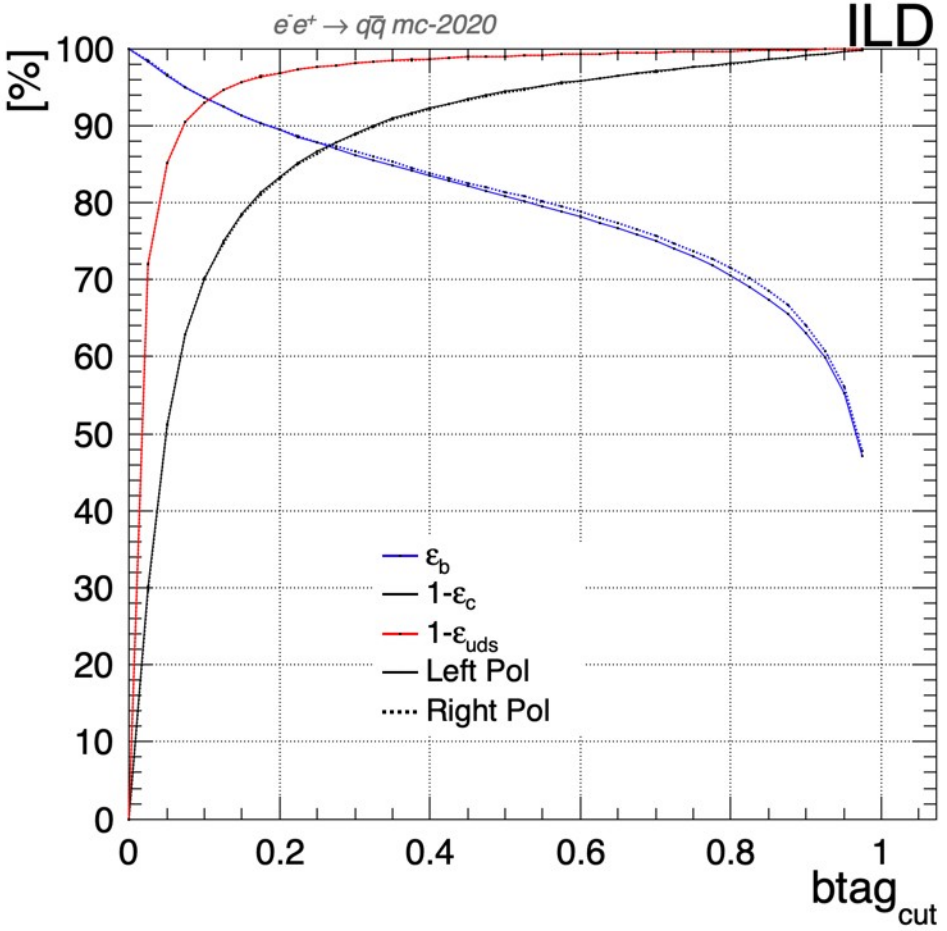
$btag_{cut}$
ε_b
$1-\varepsilon_c$
$1-\varepsilon_{uds}$
Left Pol
Right Pol

b-tag – Cut 6


$e^-e^+ \to q\bar{q}$ mc-2020
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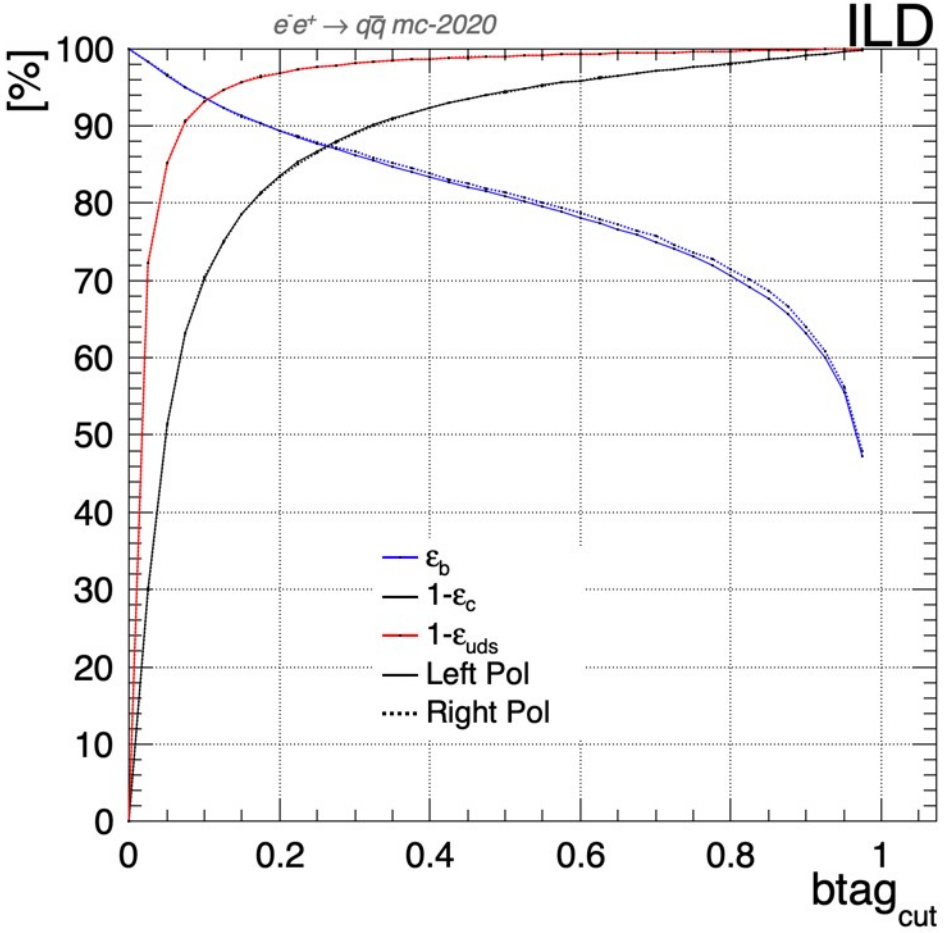
btag$_{cut}$
ε_b
1-ε_c
1-ε_{uds}
Left Pol
Right Pol

b-tag – Cut 7


$e^-e^+ \rightarrow q\bar{q}$ mc-2020
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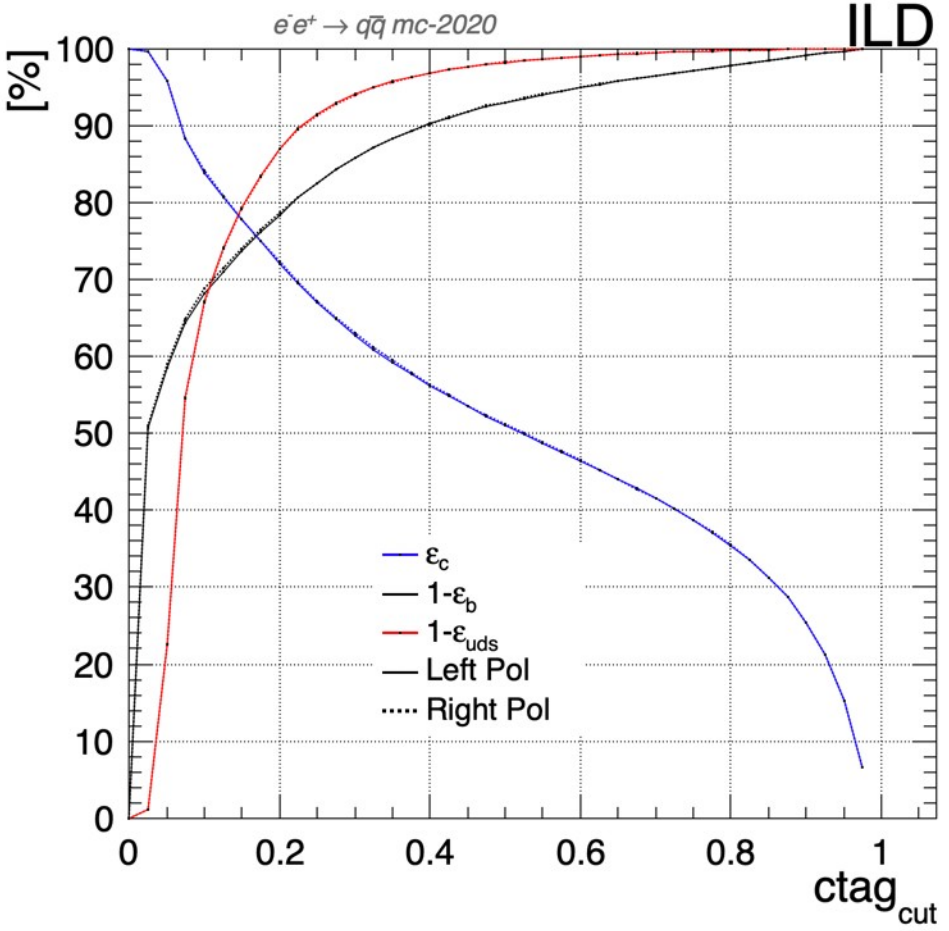
$btag_{cut}$
ε_b
$1-\varepsilon_c$
$1-\varepsilon_{uds}$
Left Pol
Right Pol

c-tag – Cut 0


$e^-e^+ \to q\bar{q}$ mc-2020
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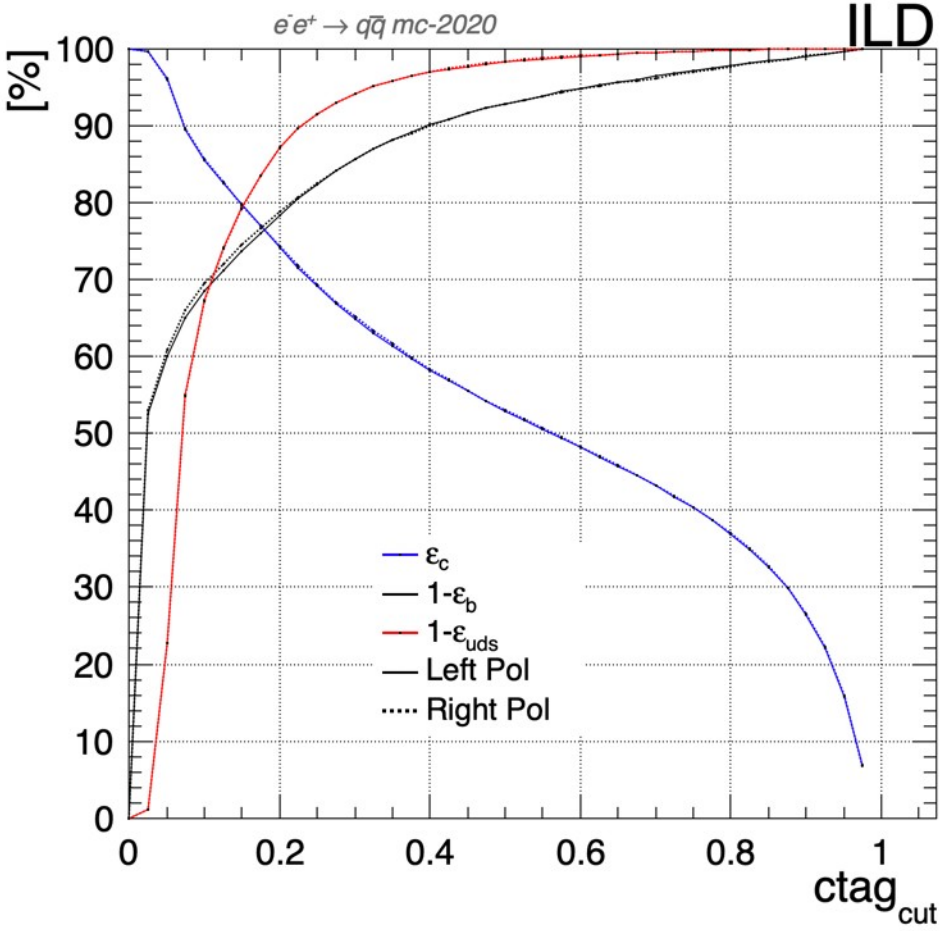
$ctag_{cut}$
ε_c
$1-\varepsilon_b$
$1-\varepsilon_{uds}$
Left Pol
Right Pol

c-tag – Cut 1


$e^-e^+ \to q\bar{q}$ mc-2020
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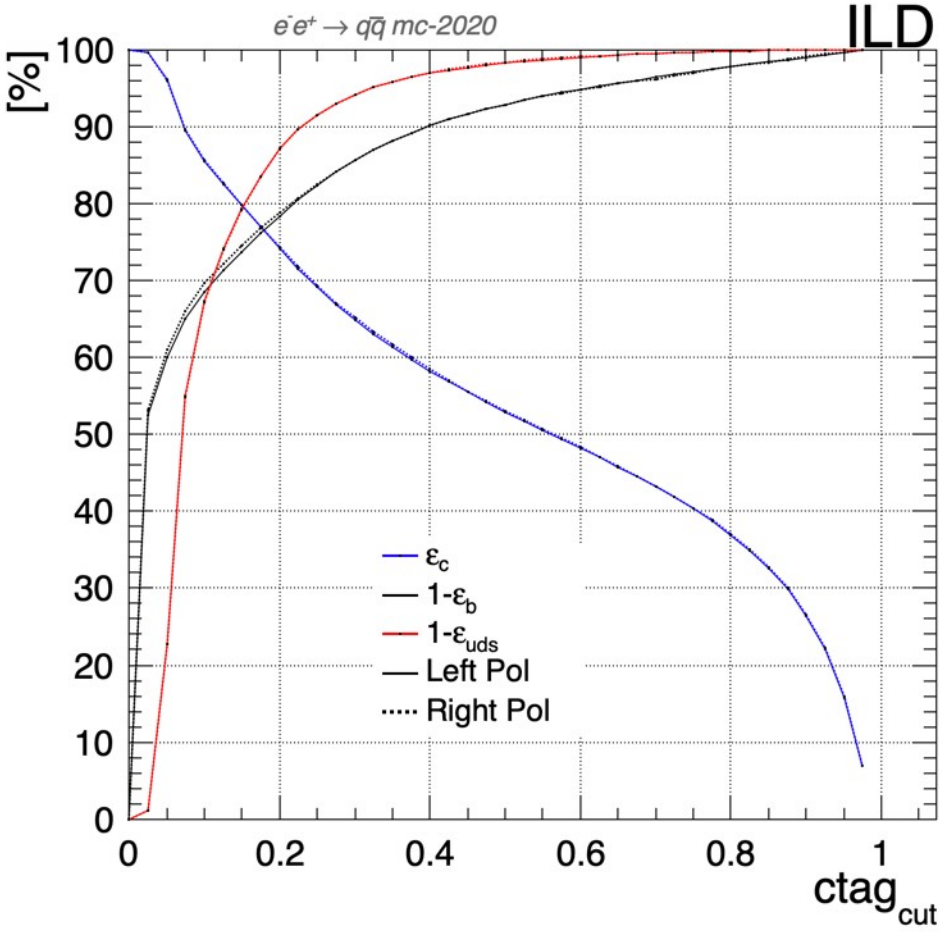
1
ctag$_{cut}$
ε_c
1-ε_b
1-ε_{uds}
Left Pol
Right Pol

c-tag – Cut 2


$e^-e^+ \to q\bar{q}$ mc-2020
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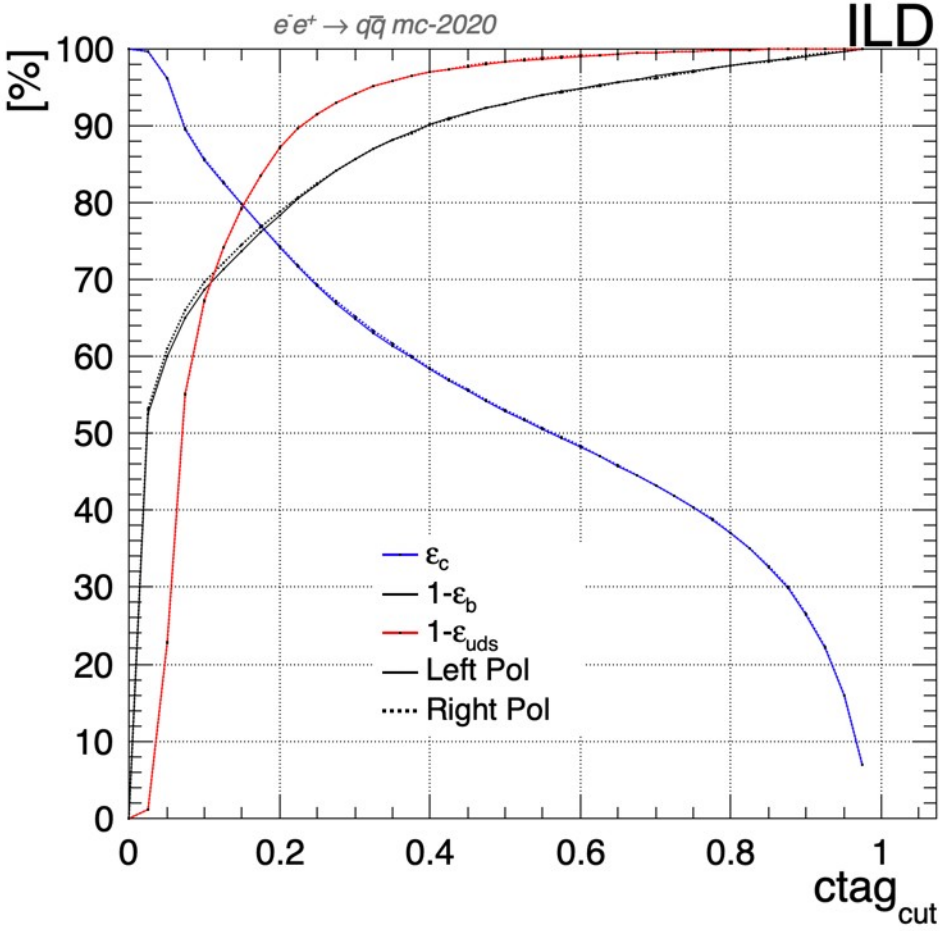
1
$ctag_{cut}$
ε_c
$1-\varepsilon_b$
$1-\varepsilon_{uds}$
Left Pol
Right Pol

c-tag – Cut 3


$e^-e^+ \to q\bar{q}$ mc-2020
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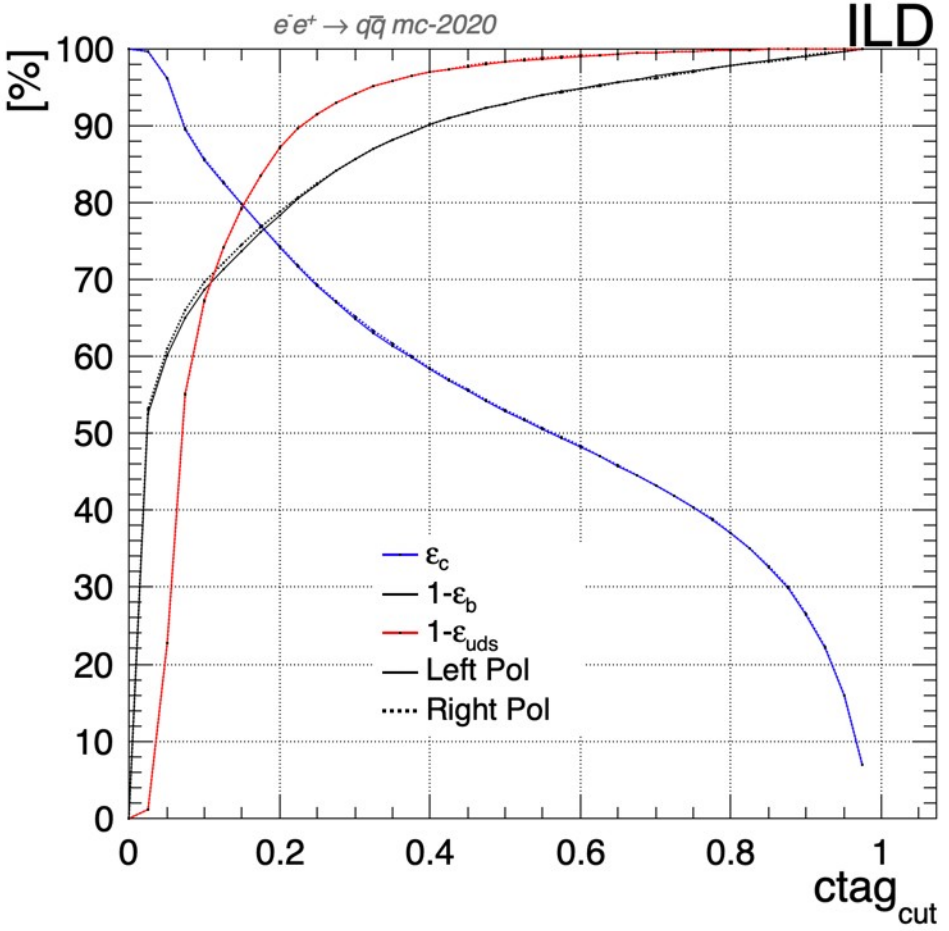
$ctag_{cut}$
ε_c
$1-\varepsilon_b$
$1-\varepsilon_{uds}$
Left Pol
Right Pol

c-tag – Cut 4


$e^-e^+ \to q\bar{q}$ mc-2020
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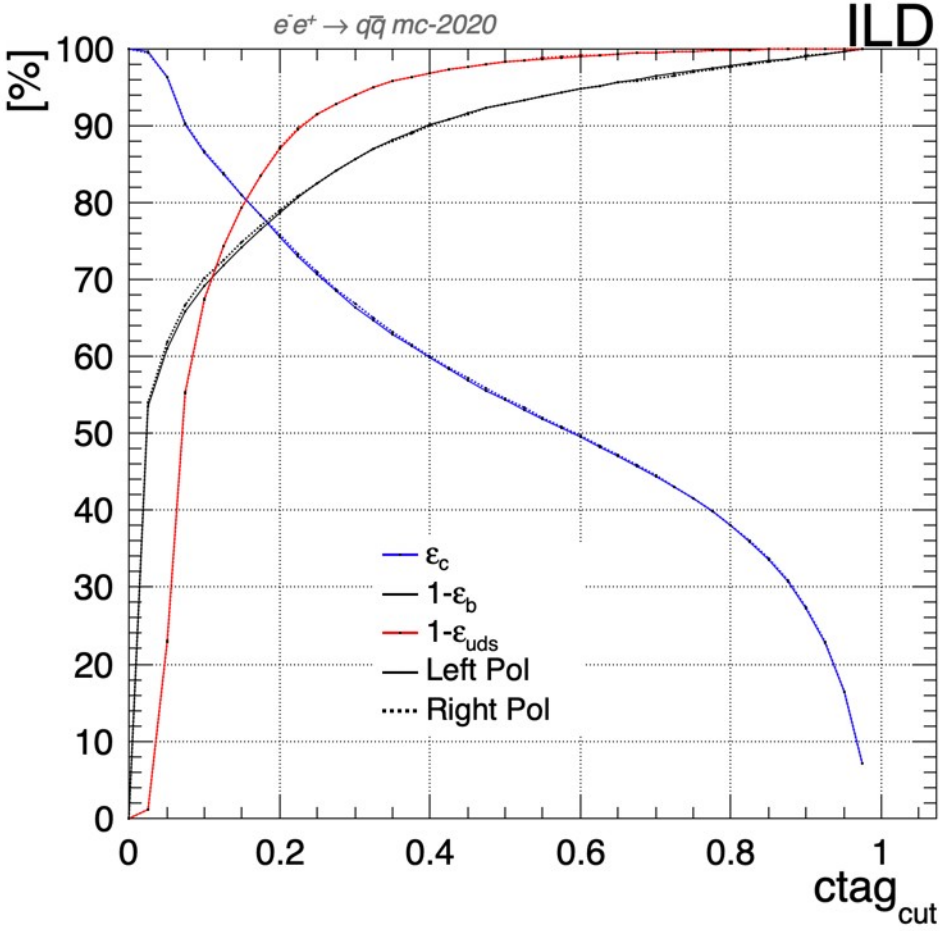
$ctag_{cut}$
ε_c
$1-\varepsilon_b$
$1-\varepsilon_{uds}$
Left Pol
Right Pol

c-tag – Cut 5


$e^-e^+ \to q\bar{q}$ mc-2020
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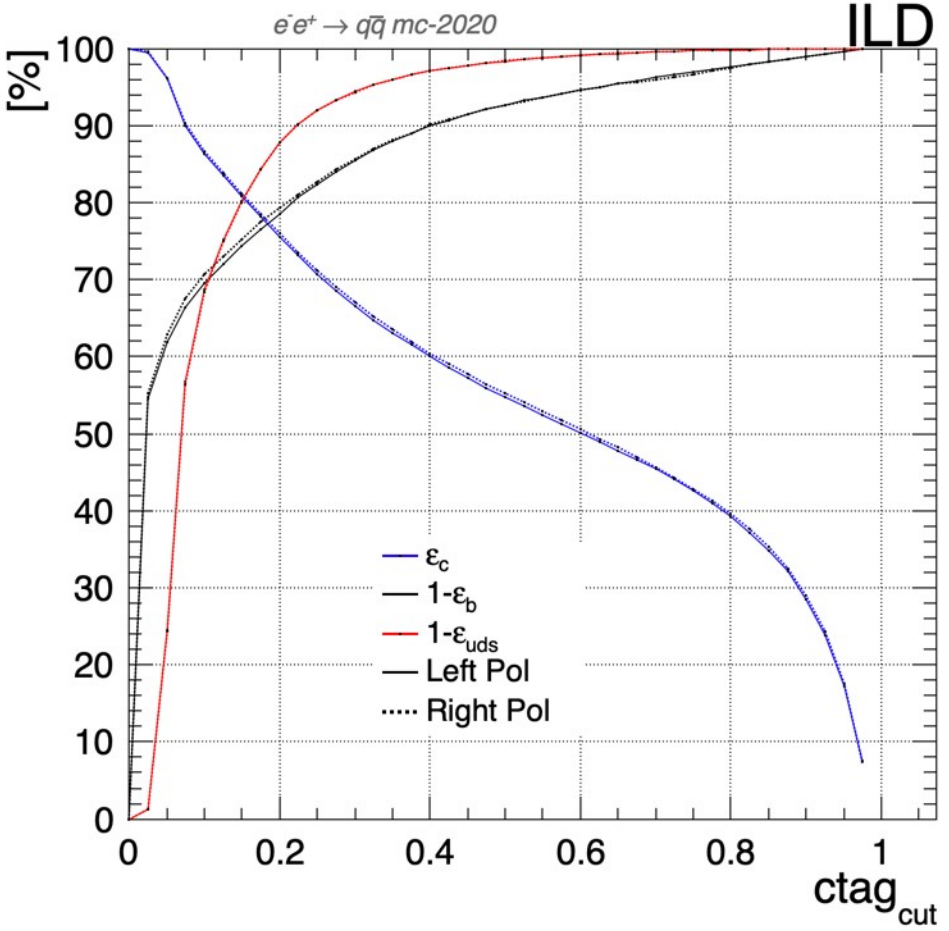
$ctag_{cut}$
ε_c
$1-\varepsilon_b$
$1-\varepsilon_{uds}$
Left Pol
Right Pol

c-tag – Cut 6


$e^-e^+ \rightarrow q\bar{q}$ mc-2020
ILD
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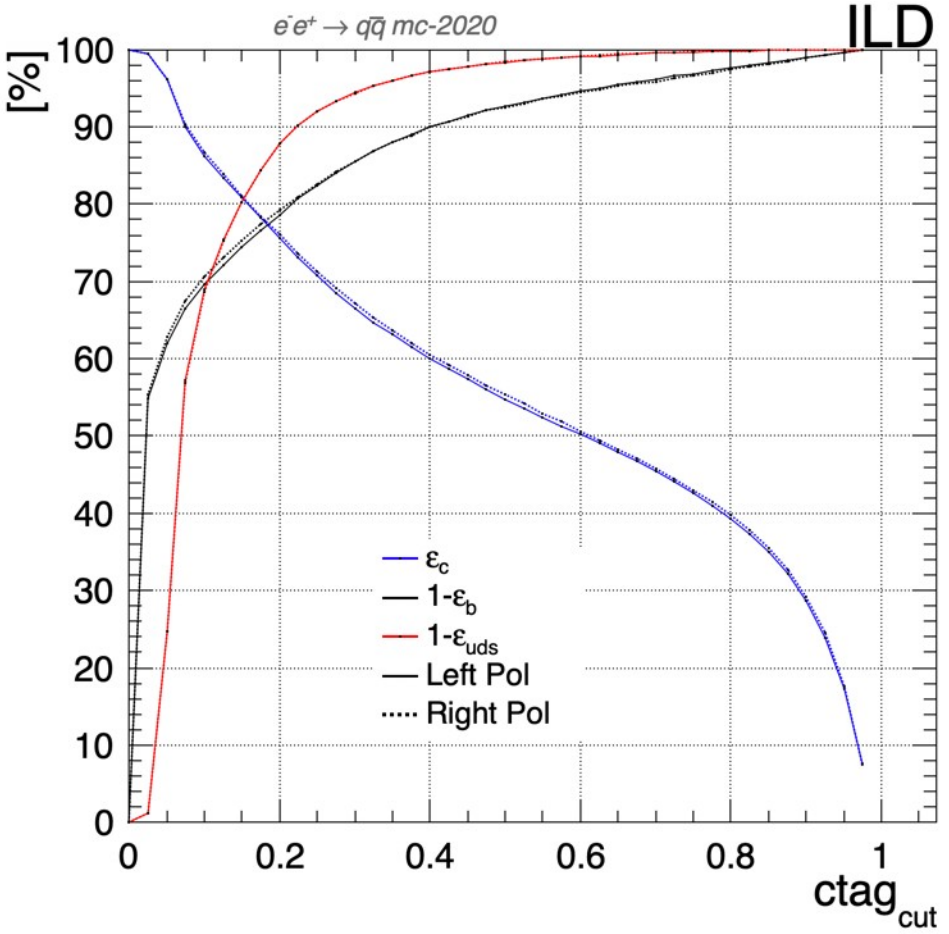
$ctag_{cut}$
ε_c
$1-\varepsilon_b$
$1-\varepsilon_{uds}$
Left Pol
Right Pol

c-tag – Cut 7


$e^-e^+ \rightarrow q\bar{q}$ mc-2020
ILD
[%]
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$ctag_{cut}$
ε_c
$1-\varepsilon_b$
$1-\varepsilon_{uds}$
Left Pol
Right Pol