Institute for Research in Fundamental Sciences

The charged Kaon Fragmentation Function

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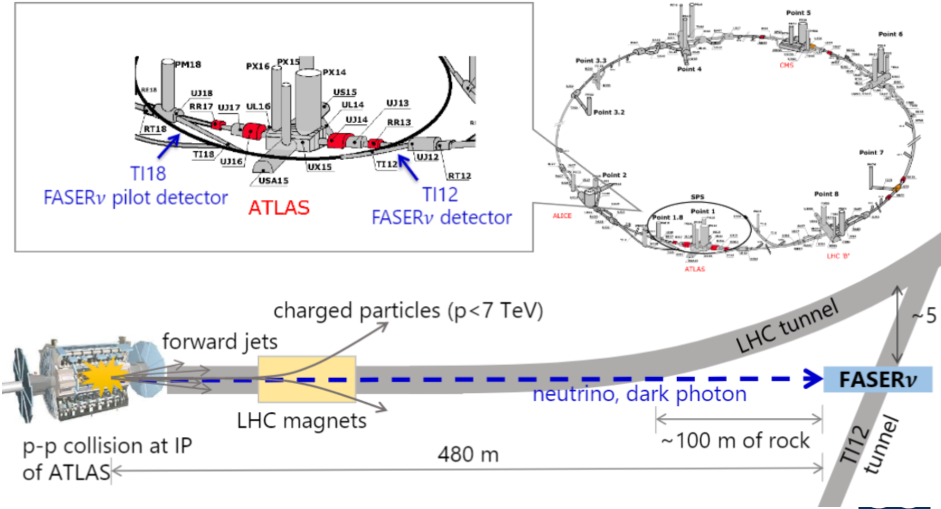
(xFitter Workshop CERN 2023)

FASERν



From FPF whitpaper

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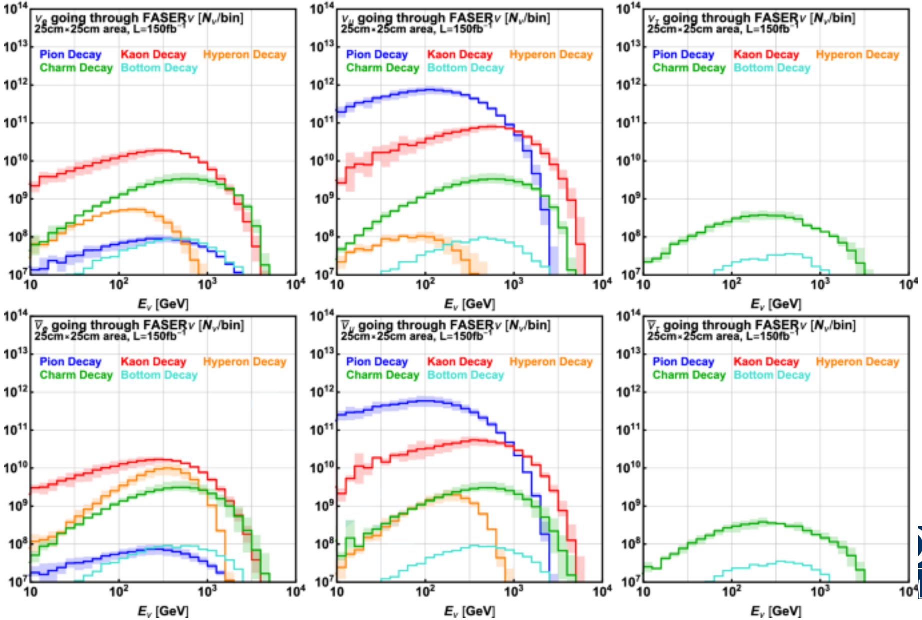

Kaon FFs

1. Same as Pion FFs strategy
   1. Data-sets: Belle20, BaBar, ...
   2. Observable: $\frac{d\sigma^h}{dz}$, $\frac{1}{\sigma}\frac{d\sigma^h}{dz}$, $\frac{1}{\sigma}\frac{d\sigma^h}{dp_h}$,...
   3. Parameterization form: $D_i^{K^\pm}(z, Q_0) = \frac{\mathcal{N}_i z^{\alpha_i}(1-z)^{\beta_i}[1+\gamma_i(1-z)^{\delta_i}]}{B[2+\alpha_i,\beta_i+1]+\gamma_i B[2+\alpha_i,\beta_i+\delta_i+1]}$, and $i = u+\bar{u}, s+\bar{s}, \ldots$

      $\int_0^1 dz\, zD_i = \mathcal{N}_i$
   4. theory calculation: (APFEL)
2. Differ on decomposition: D_{u^+}, D_{d^+}, D_{s^+}, D_{c^+}, D_{b^+} and D_g

   $D_q = D_{\bar{q}} = \frac{1}{2} D_{q^+}$

NOTE: This analysis is the same as Our Pion FFs analysis in data and methodology but defer on decomposition.

- FitA: We impose a $z > 0.2$ cut for $\sqrt{s} = M_z$ and a $z > 0.075$ cut for other C.M
- FitB: Like FitA, We exclude Belle data.
- FitC: Like FitA, We exclude BaBar data.
- FitD: Like FitA, we impose a $z > 0.2$ cut for BaBar
- FitE: Like FitD, we impose a $z > 0.2$ cut for Belle
- FitF: We impose a $z > 0.1$ cut for BaBar and a $x > 0.2$ cut for Belle (same of FitE in our Pion Paper)

Dataset	FitA	FitB	FitC	FitD	FitE	FitF
SLD b^k_{tag}	86 / 35	121 / 35	89 / 35	90 / 35	90 / 35	89 / 35
$DELPHI^k_{TOT}$	26 / 22	18 / 22	16 / 22	17 / 22	16 / 22	20 / 22
$TASSO^k_{22}$	21 / 6	21 / 6	10 / 6	8.1 / 6	6.3 / 6	16 / 6
TPC^k_{TOT}	39 / 13	35 / 13	5.3 / 13	17 / 13	21 / 13	63 / 13
$ALEPH^k_{TOT}$	51 / 18	30 / 18	16 / 18	19 / 18	18 / 18	24 / 18
SLD c^k_{tag}	124 / 35	146 / 35	41 / 35	44 / 35	42 / 35	125 / 35
$OPAL^k_{TOT}$	14 / 10	16 / 10	8.8 / 10	8.5 / 10	8.7 / 10	7.3 / 10
$TASSO^k_{34}$	2.0 / 5	2.2 / 5	0.80 / 5	0.50 / 5	0.38 / 5	2.1 / 5
$TASSO^k_{14}$	18 / 9	17 / 9	15 / 9	13 / 9	14 / 9	16 / 9
$TASSO^k_{12}$	6.8 / 3	7.0 / 3	5.8 / 3	4.5 / 3	4.2 / 3	6.9 / 3
DELPHI $light^k_{tag}$	26 / 22	31 / 22	24 / 22	23 / 22	24 / 22	22 / 22
DELPHI b^k_{tag}	18 / 22	16 / 22	15 / 22	16 / 22	16 / 22	25 / 22
SLD^k_{TOT}	34 / 35	30 / 35	14 / 35	18 / 35	17 / 35	18 / 35
SLD $light^k_{tag}$	100 / 35	68 / 35	60 / 35	62 / 35	62 / 35	79 / 35
$BABAR^k$	151 / 43	203 / 43	-	30 / 28	25 / 28	247 / 43
$BELLE2020^k$	95 / 32	-	13 / 32	102 / 32	75 / 28	98 / 28
Correlated χ^2	8.9	8.5	3.3	1.5	1.2	7.3
Log penalty χ^2	+12	+8.7	+2.8	+9.2	+9.3	+13
Total χ^2 / dof	834 / 327	778 / 295	341 / 284	483 / 312	450 / 308	877 / 323
	2.55	2.64	1.2	1.54	1.46	2.7

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$TASSO^k_{12}$	6.8 / 3	7.0 / 3	5.8 / 3	4.5 / 3	4.2 / 3	6.9 / 3
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DELPHI b^k_{tag}	18 / 22	16 / 22	15 / 22	16 / 22	16 / 22	25 / 22
SLD^k_{TOT}	34 / 35	30 / 35	14 / 35	18 / 35	17 / 35	18 / 35
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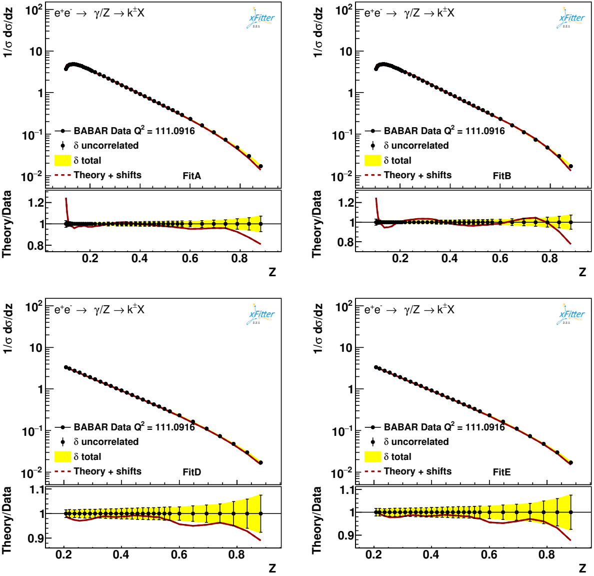
	2.55	2.64	1.2	1.54	1.46	2.7

- Note that when we exclude Babar data on Fit C the total χ^2 and individual χ^2 for the Belle and other data sets especially for SLD decreased. This mean thera are intention between Babar and other data sets, We expect similar behavior when we exclude Belle data on Fit B, But we could see the individual χ^2 for Babar and also SLD data increased. this means Belle data more compatible with other data than Babar.
- we follow the strategy that we used for Pion paper, We see that there are tension between Babar and Belle data which is solve by impose the $x > 0.2$ cut for belle data and a $x > 0.1$ for Babar data, by comparison Fits presented on table and data description plot, we find that we couldnt solve this tention in Kaon FFs case by impose a cut on the data.
- I recommend, we could extract Kaon FFs by Fit C where we exclude Babar data.

BaBar

$x > 0.075$

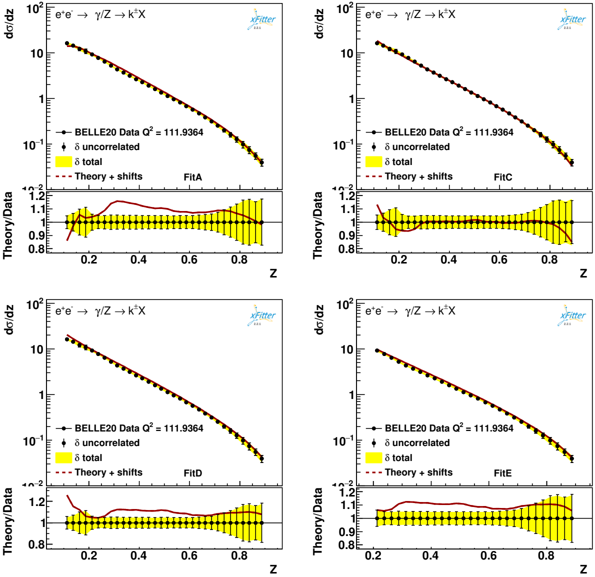
$x > 0.2$



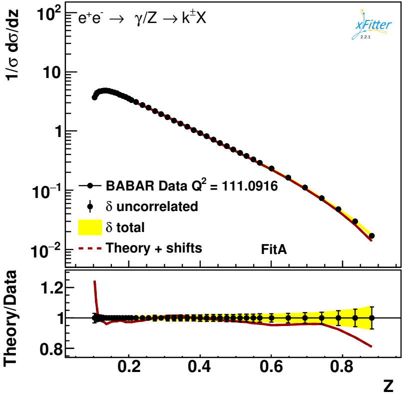
Belle

$x > 0.075$

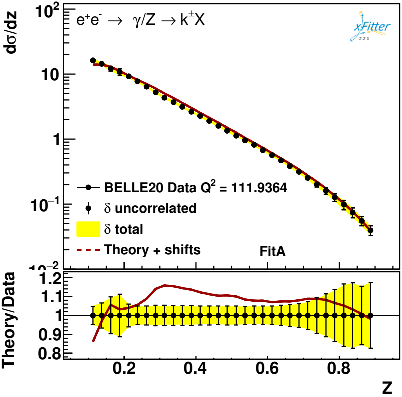
$x > 0.2$



Fit A

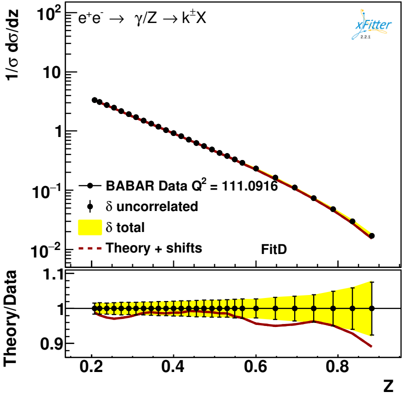


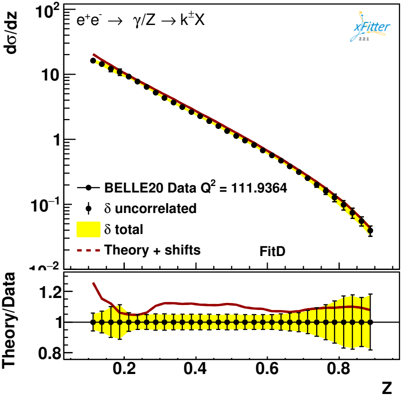
$x > 0.075$



$x > 0.075$

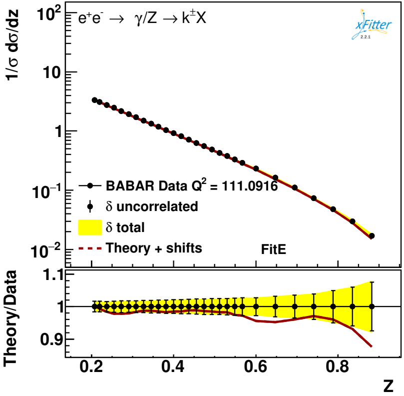
Fit D





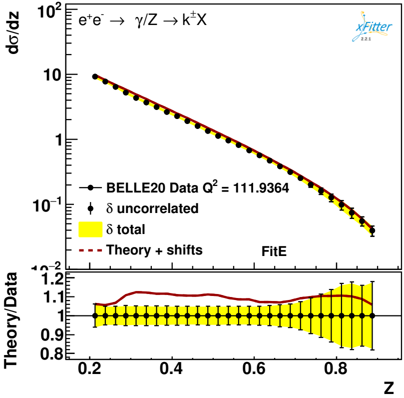
$x > 0.2$ $x > 0.075$

Fit E



$e^+e^- \to \gamma/Z \to k^\pm X$
xFitter
2.2.1
$1/\sigma\ d\sigma/dz$
10^2
10
1
10^{-1}
10^{-2}
BABAR Data Q^2 = 111.0916
δ uncorrelated
δ total
Theory + shifts
FitE
Theory/Data
1.1
1
0.9
0.2
0.4
0.6
0.8
z

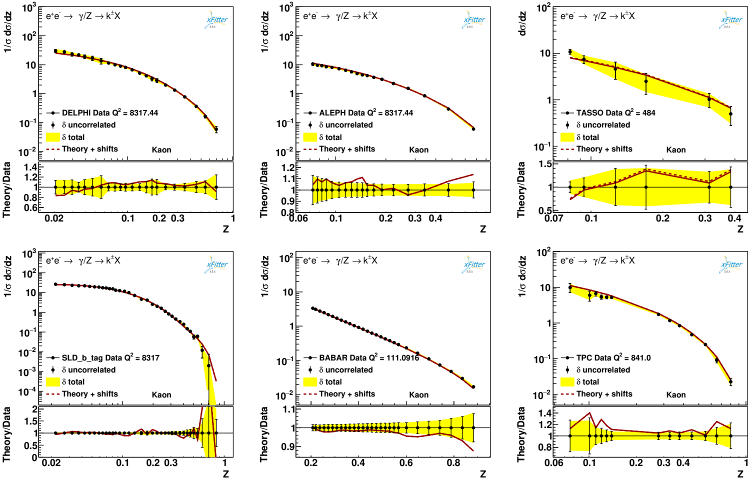
$x > 0.2$



$e^+e^- \to \gamma/Z \to k^\pm X$
xFitter
2.2.1
$d\sigma/dz$
10^2
10
1
10^{-1}
10^{-2}
BELLE20 Data Q^2 = 111.9364
δ uncorrelated
δ total
Theory + shifts
FitE
Theory/Data
1.2
1.1
1
0.9
0.8
0.2
0.4
0.6
0.8
z

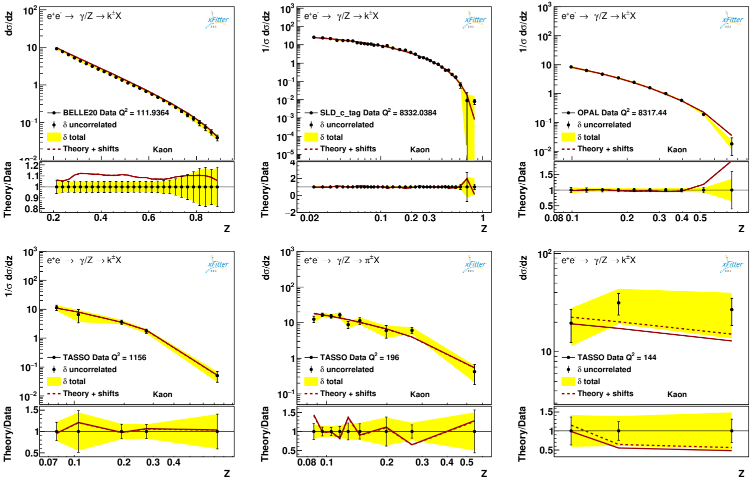
$x > 0.2$

Fit Results

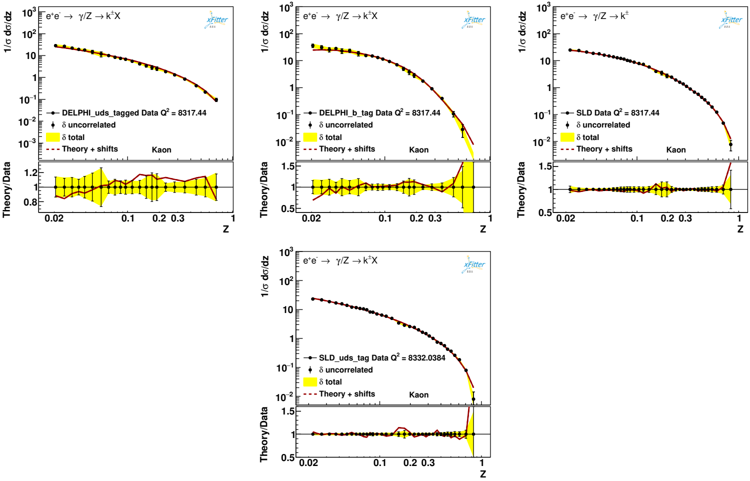


e+e- → γ/Z → k±X
xFitter
1/σ dσ/dz
Theory/Data
DELPHI Data Q² = 8317.44
δ uncorrelated
δ total
Theory + shifts
Kaon
ALEPH Data Q² = 8317.44
TASSO Data Q² = 484
dσ/dz
SLD_b_tag Data Q² = 8317
BABAR Data Q² = 111.0916
TPC Data Q² = 841.0
z

Fit Results

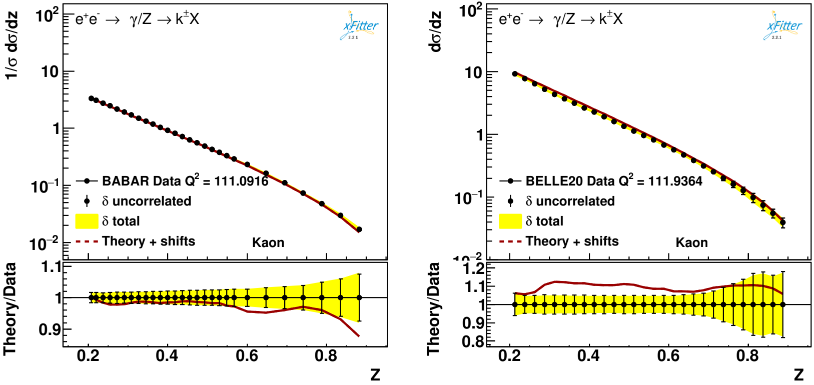

e+e- → γ/Z → k±X
BELLE20 Data Q² = 111.9364
δ uncorrelated
δ total
Theory + shifts
Kaon
dσ/dz
Theory/Data
z
e+e- → γ/Z → k±X
SLD_c_tag Data Q² = 8332.0384
δ uncorrelated
δ total
Theory + shifts
Kaon
1/σ dσ/dz
Theory/Data
z
e+e- → γ/Z → k±X
OPAL Data Q² = 8317.44
δ uncorrelated
δ total
Theory + shifts
Kaon
1/σ dσ/dz
Theory/Data
z
e+e- → γ/Z → k±X
TASSO Data Q² = 1156
δ uncorrelated
δ total
Theory + shifts
Kaon
1/σ dσ/dz
Theory/Data
z
e+e- → γ/Z → π±X
TASSO Data Q² = 196
δ uncorrelated
δ total
Theory + shifts
Kaon
dσ/dz
Theory/Data
z
e+e- → γ/Z → k±X
TASSO Data Q² = 144
δ uncorrelated
δ total
Theory + shifts
Kaon
dσ/dz
Theory/Data
z
xFitter

Fit Results



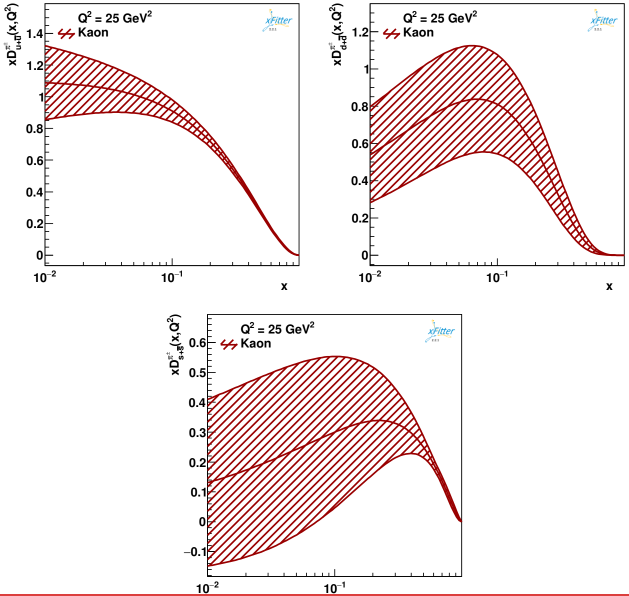
e+e- → γ/Z → k±X
xFitter
DELPHI_uds_tagged Data Q² = 8317.44
δ uncorrelated
δ total
Theory + shifts
Kaon
DELPHI_b_tag Data Q² = 8317.44
SLD Data Q² = 8317.44
SLD_uds_tag Data Q² = 8332.0384
1/σ dσ/dz
Theory/Data
z

Fit Results



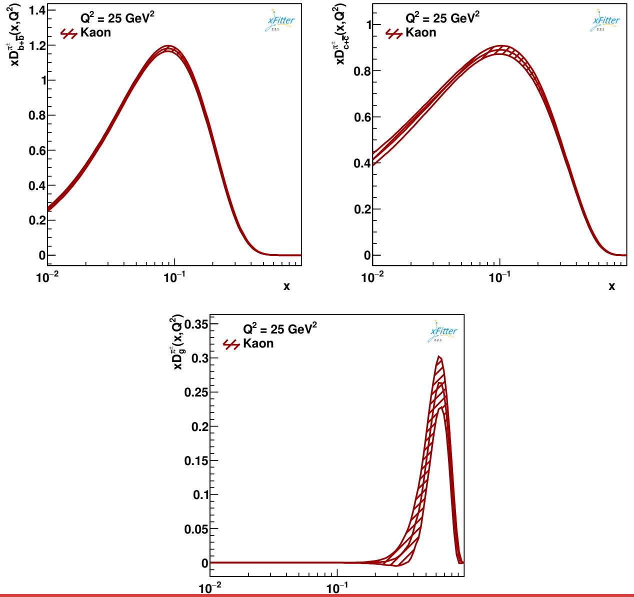
$e^+e^- \to \gamma/Z \to k^\pm X$
xFitter
1/σ dσ/dz
BABAR Data Q^2 = 111.0916
δ uncorrelated
δ total
Theory + shifts
Kaon
Theory/Data
Z
dσ/dz
BELLE20 Data Q^2 = 111.9364

Fit Results



Q^2 = 25 GeV^2
Kaon
$xD^{\pi^\pm}_{u+\bar{u}}(x,Q^2)$
x
Q^2 = 25 GeV^2
Kaon
$xD^{\pi^\pm}_{d+\bar{d}}(x,Q^2)$
x
Q^2 = 25 GeV^2
Kaon
$xD^{\pi^\pm}_{s+\bar{s}}(x,Q^2)$
xFitter

Fit Results


Q^2 = 25 GeV^2
Kaon
xFitter
$xD^{\pi^\pm}_{b+\bar{b}}(x,Q^2)$
1.4
1.2
1
0.8
0.6
0.4
0.2
0
10^{-2}
10^{-1}
x
Q^2 = 25 GeV^2
Kaon
xFitter
$xD^{\pi^\pm}_{c+\bar{c}}(x,Q^2)$
1
0.8
0.6
0.4
0.2
0
10^{-2}
10^{-1}
x
Q^2 = 25 GeV^2
Kaon
xFitter
$xD^{\pi^\pm}_{g}(x,Q^2)$
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
10^{-2}
10^{-1}

Thank you