Inclusive $\pi^0/K_s/\eta/\phi$ @ BESIII

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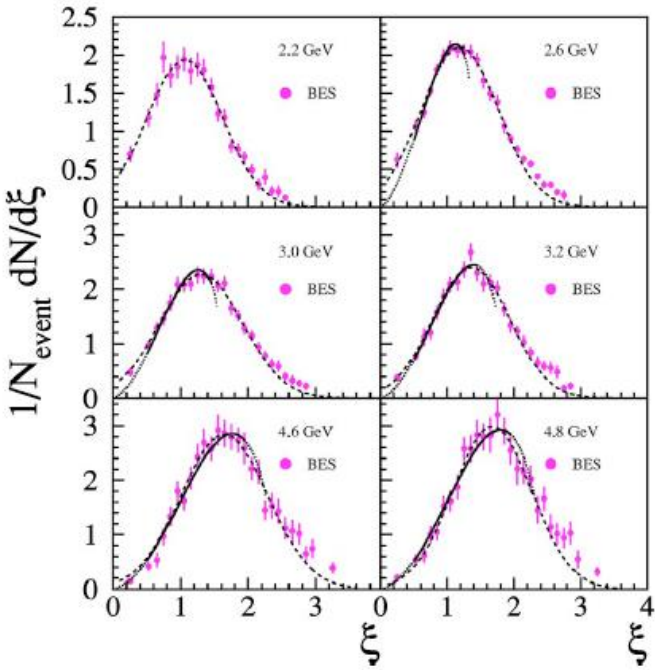
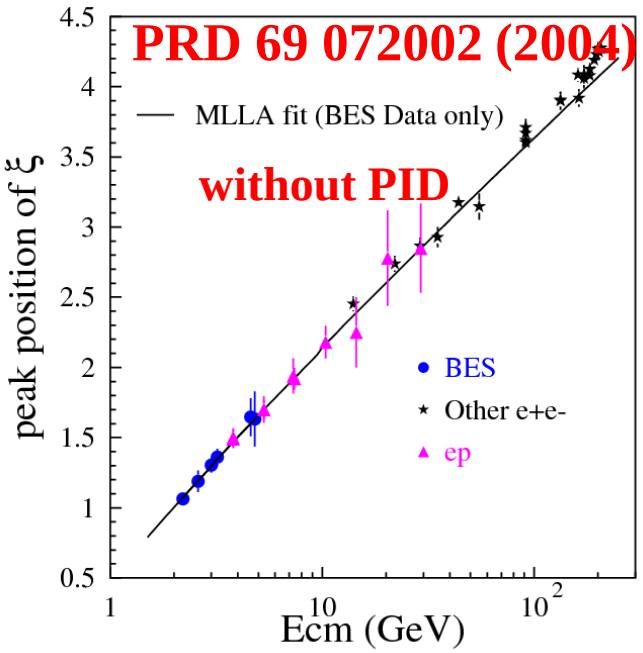
MLLA/LPHD prediction

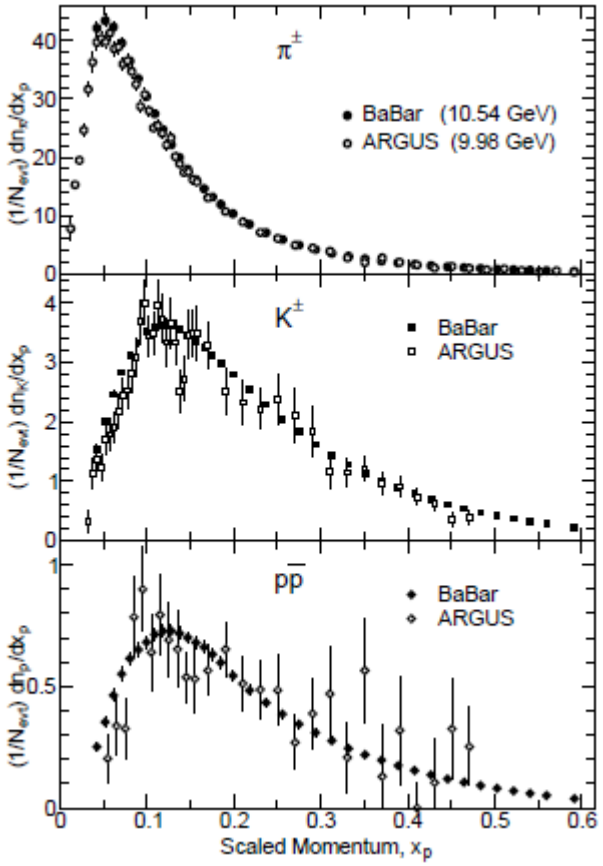
- **MLLA**: Modified Leading Log Approximation
  - ➢calculating partonic distribution
- **LPHD**: Local Parton Hadronic Duality
  - ➢bridge of partonic distribution & hadronic distribution

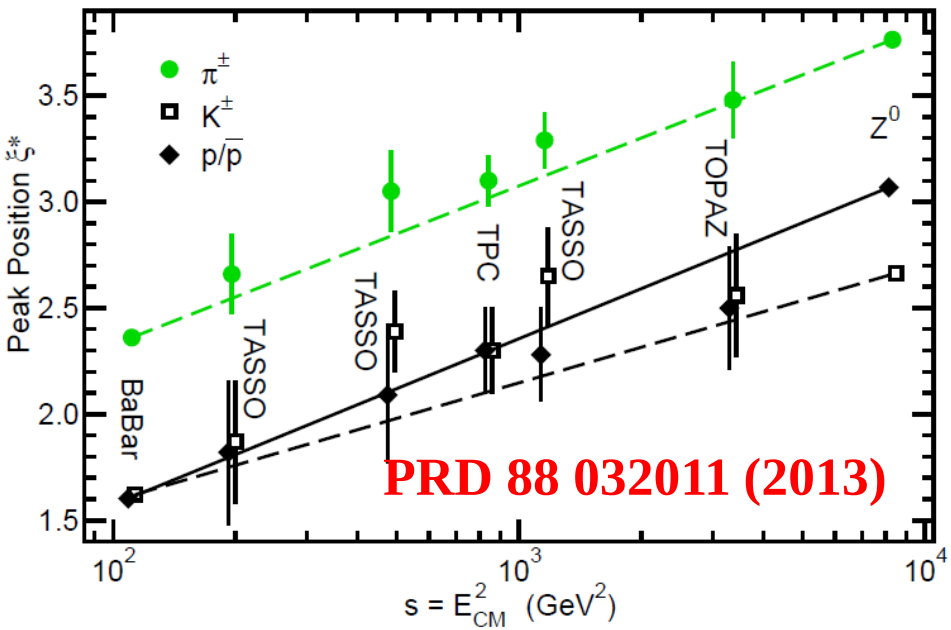




- The fitted line by BES data could descrtibe high energy e+e- data and ep data at 5% level.

- e+e- → h + X: hadron h is identified with PID



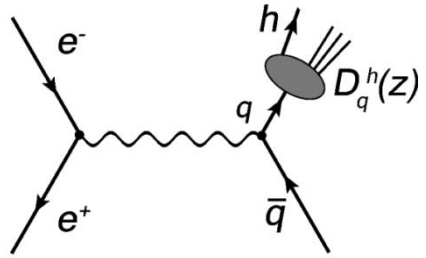


- data with $\sqrt{s}$ < 10.0 GeV: **???**

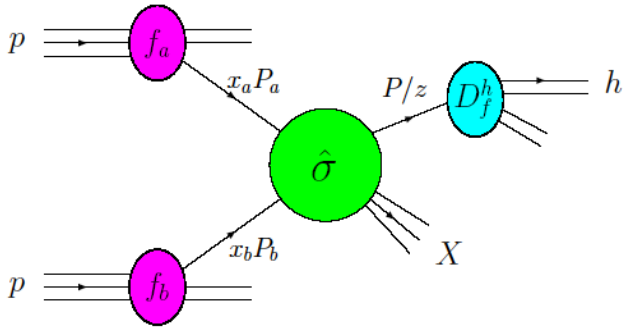
- Inclusive identified hadron at BESIII @ $\sqrt{s}$ **=[2.0, 3.65]GeV**

Fragmentation function

- Fragmentation function (FF) $D_q^h(z)$: probability that hadron h is found in the debris of a parton carrying a fraction z of parton's energy



LO $$\frac{d\sigma}{dz}(e^-e^+ \to hX) = \sum_q \sigma(e^-e^+ \to q\bar{q})\left[D_q^h(z) + D_{\bar{q}}^h(z)\right]$$

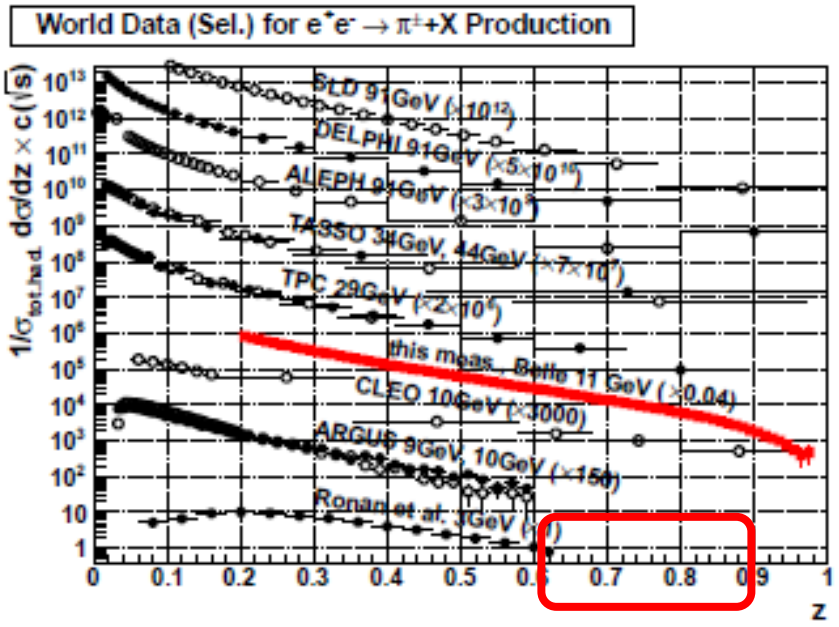


$$\sigma = \sum_{a,b,c} f_a(x_a, Q^2) \otimes f_b(x_b, Q^2)$$

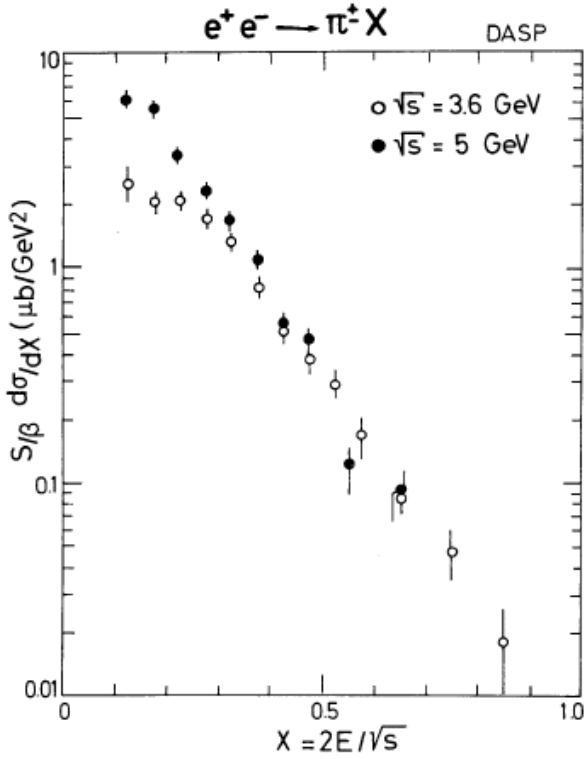
$$\otimes \hat{\sigma}(ab \to cX) \otimes D_c^{\pi}(z, Q^2)$$

- FF: QCD first principle (NOT YET);
  - FF evolution function: DGLAP (similar to that of PDF)
  - Fitting: parametrization & experimental data (e^+e^-, SIDIS, pp and p $\bar{p}$)

$e^+e^- \rightarrow \pi + X$



PRL 111 062002 (2013)

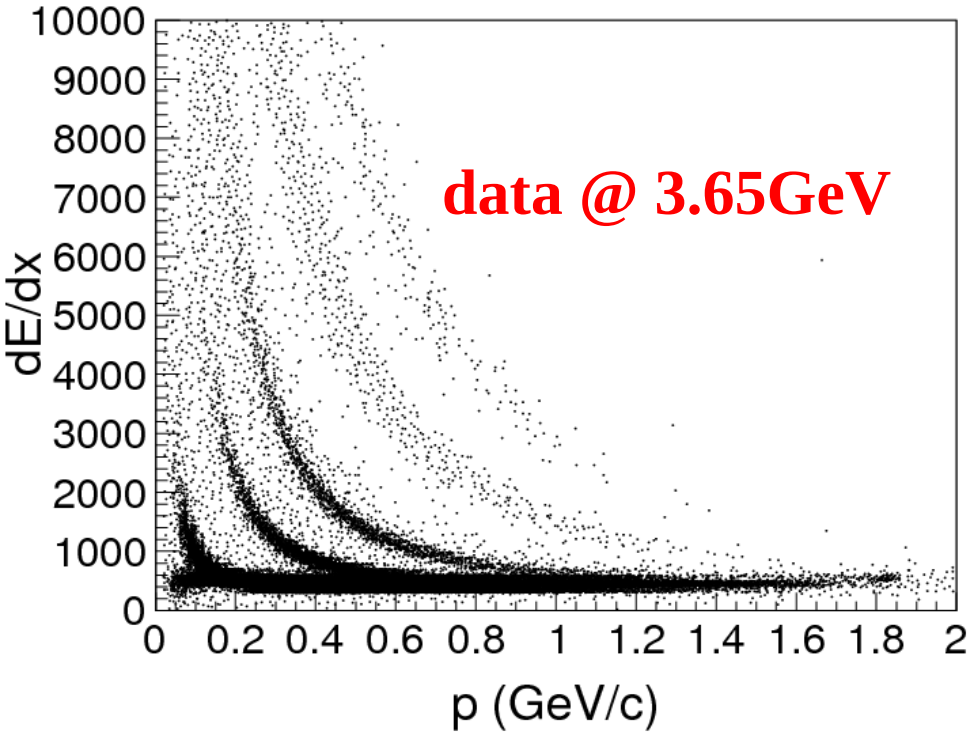


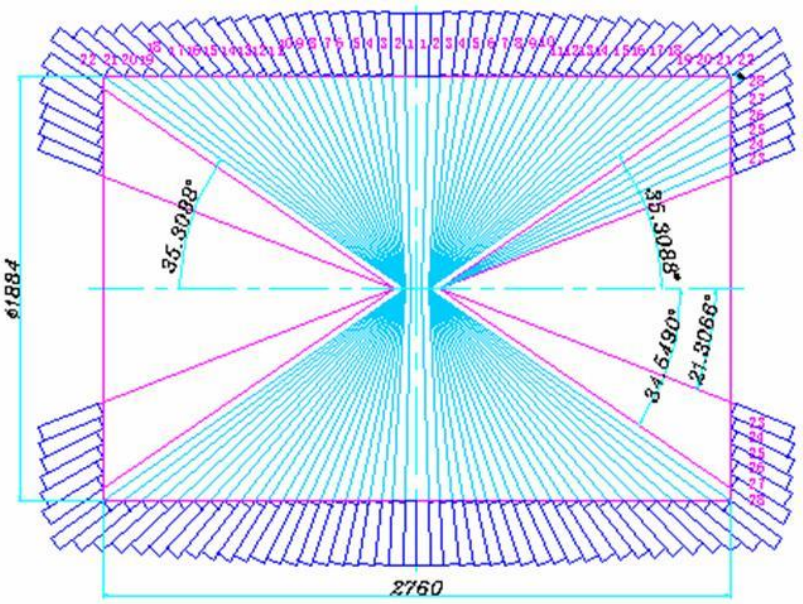
NPB 148 189 (1979)

- Lack of data at **low energy scale**
  - BESIII energy: [2, 4.6]GeV
  - Poor precision
- Lack data **at high** $z=2E_{hadron}/\sqrt{s}$

- DASP: about 35 years ago
- Stat. uncertainty: 18%

$e^+e^- \rightarrow \pi^0 + X$



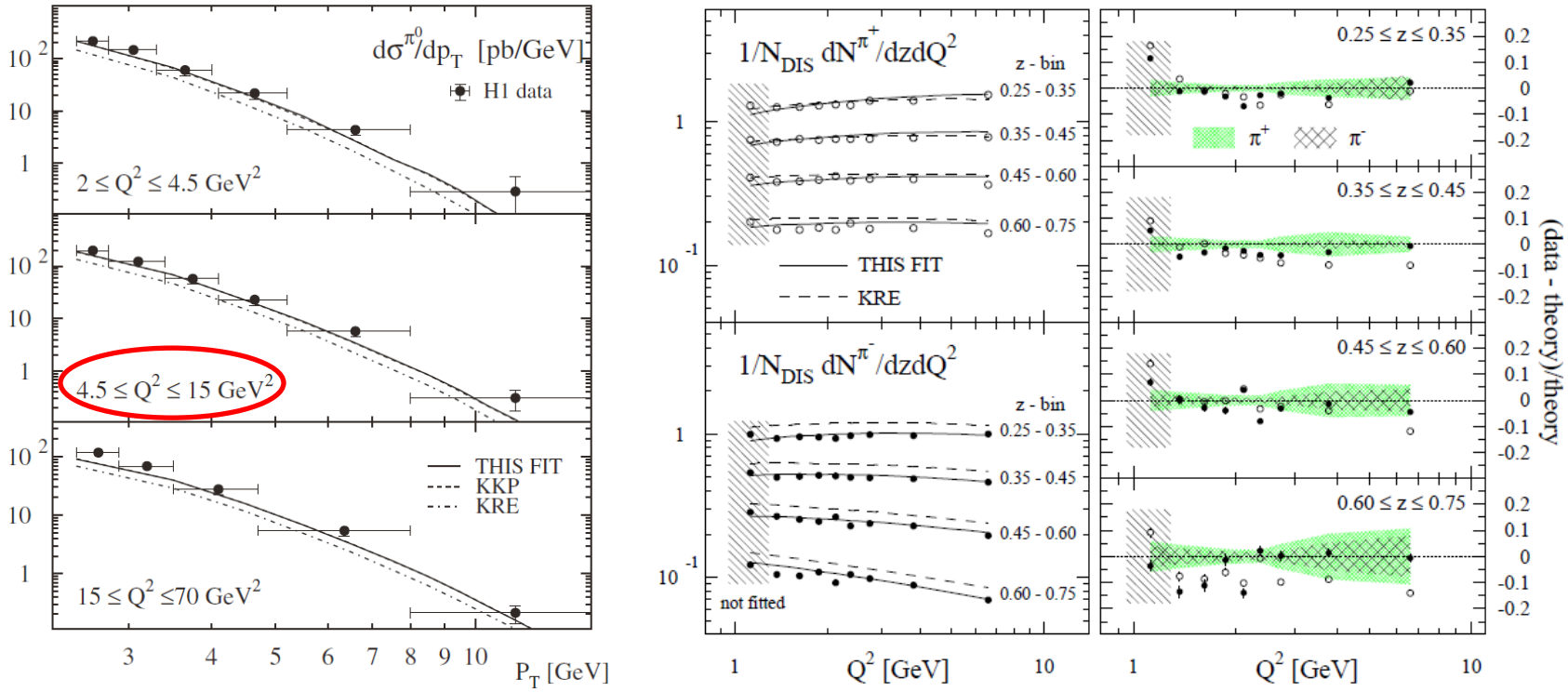


Resolution	Energy	Position
Barrel	2.5%@1GeV	6mm@1GeV
Endcap	5.0%@1GeV	9mm@1GeV

- BESIII: **?** σ for p/K @ **???**GeV
  - dE/dx & TOF for PID
- Data at **high $z=2E_{hadron}/\sqrt{s}$**: **NO**

- $\pi^0 \rightarrow 2\gamma$ with EMC
- $e^+e^- \rightarrow \pi^0 + X$ @BESIII

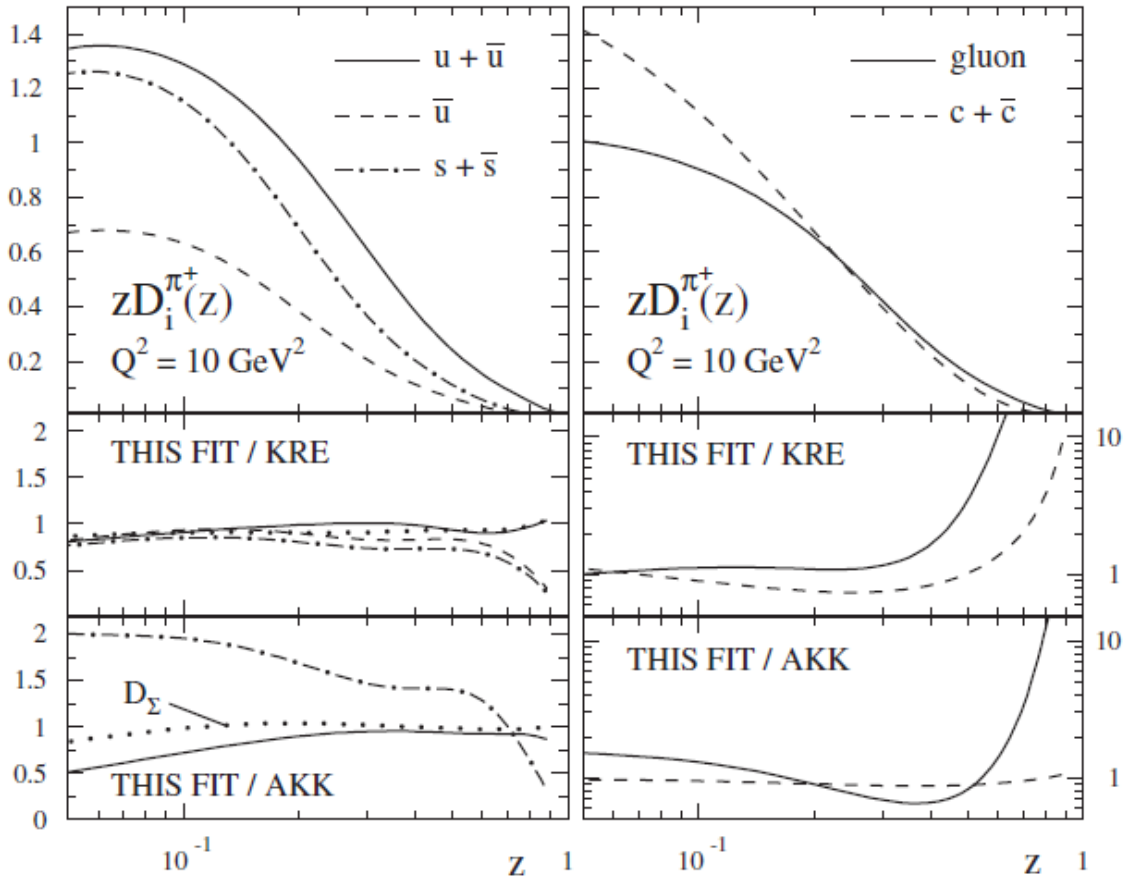
- Sets of FFs: KRE, HKNS, DSS, AKK:



PRD 75 114010 (2007)

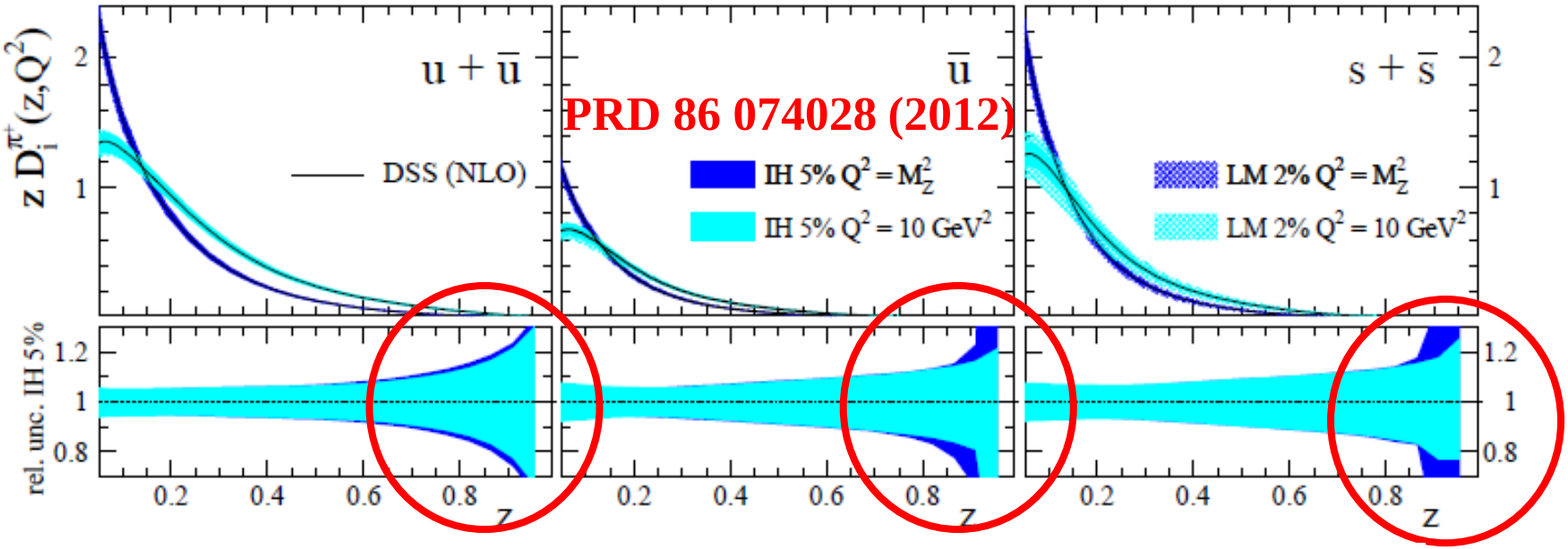
- DSS FFs could describe H1 ep neutral pion's pt data.
- DSS FFs could describe HERMES ep pion data at 10% level.
- Born level: DIS Q^2 = e^+e^- cms s; e^+e^- data at low energy s: ???

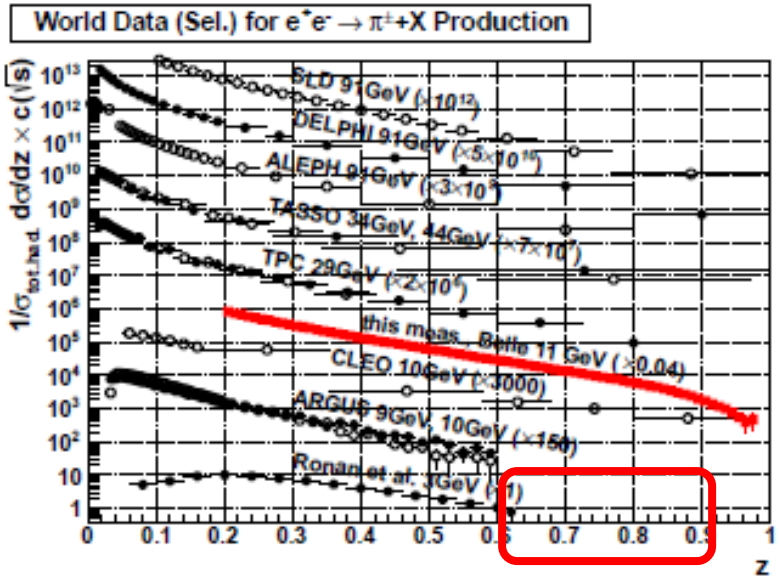
PRD 75 114010 (2007)

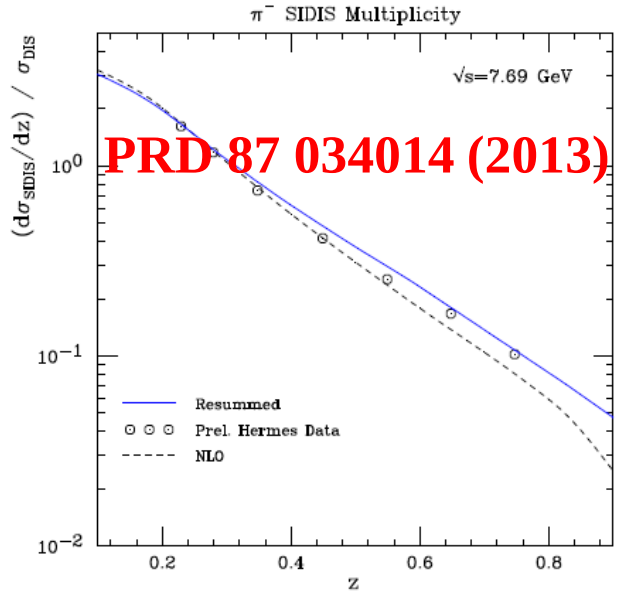


- $D^{\pi+}_{s+\bar{s}}$ @ DSS >> $D^{\pi+}_{s+\bar{s}}$ @ AKK for $z \leq 0.7$
- $D^{\pi+}_{g}$ @ DSS >> $D^{\pi+}_{g}$ @ KRE / AKK at large z

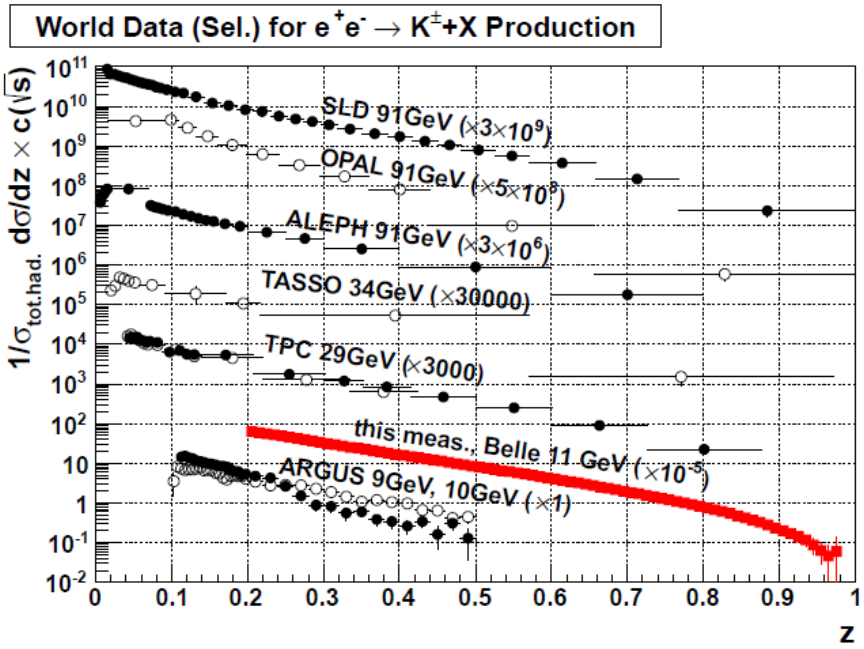
- **Theory predictions at high z: with lage uncerainty**



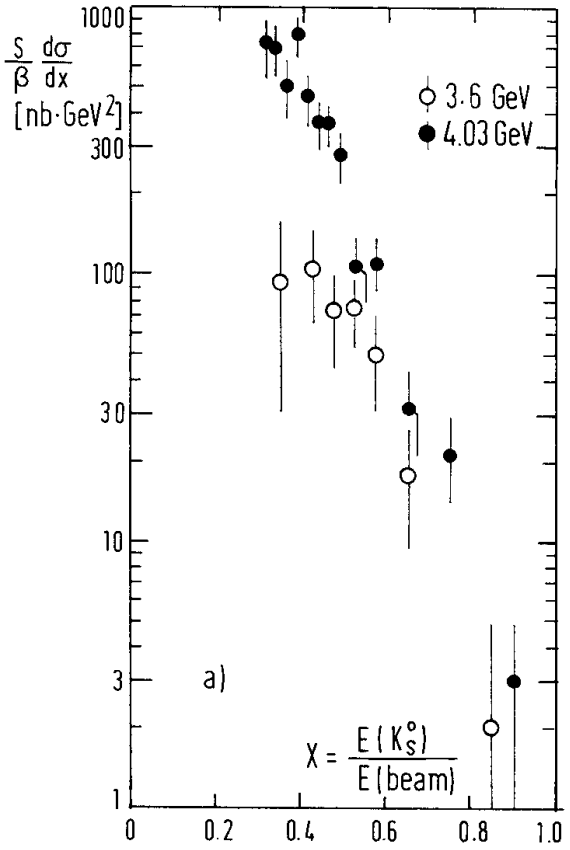




$e^+e^- \rightarrow K + X$



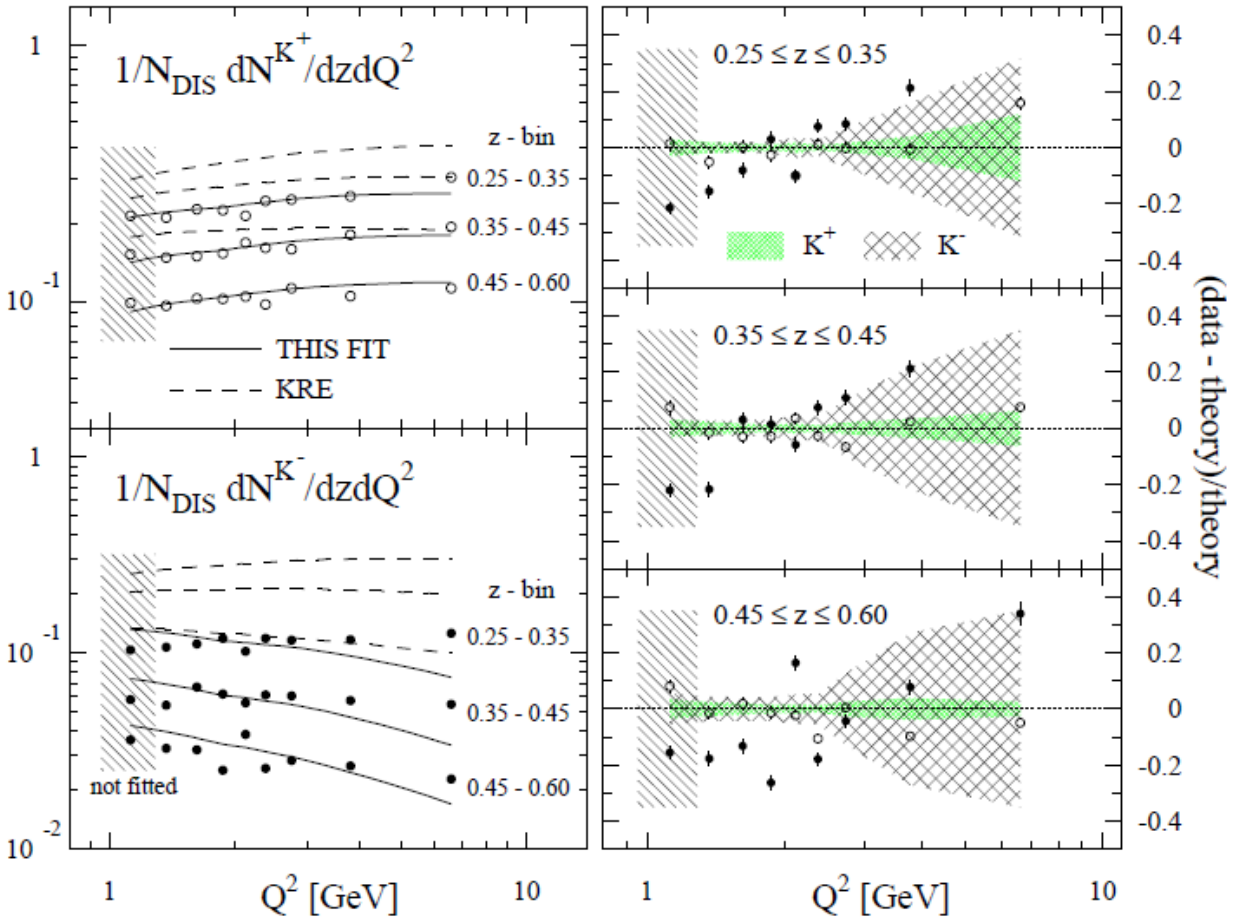
PRL 111 062002 (2013)



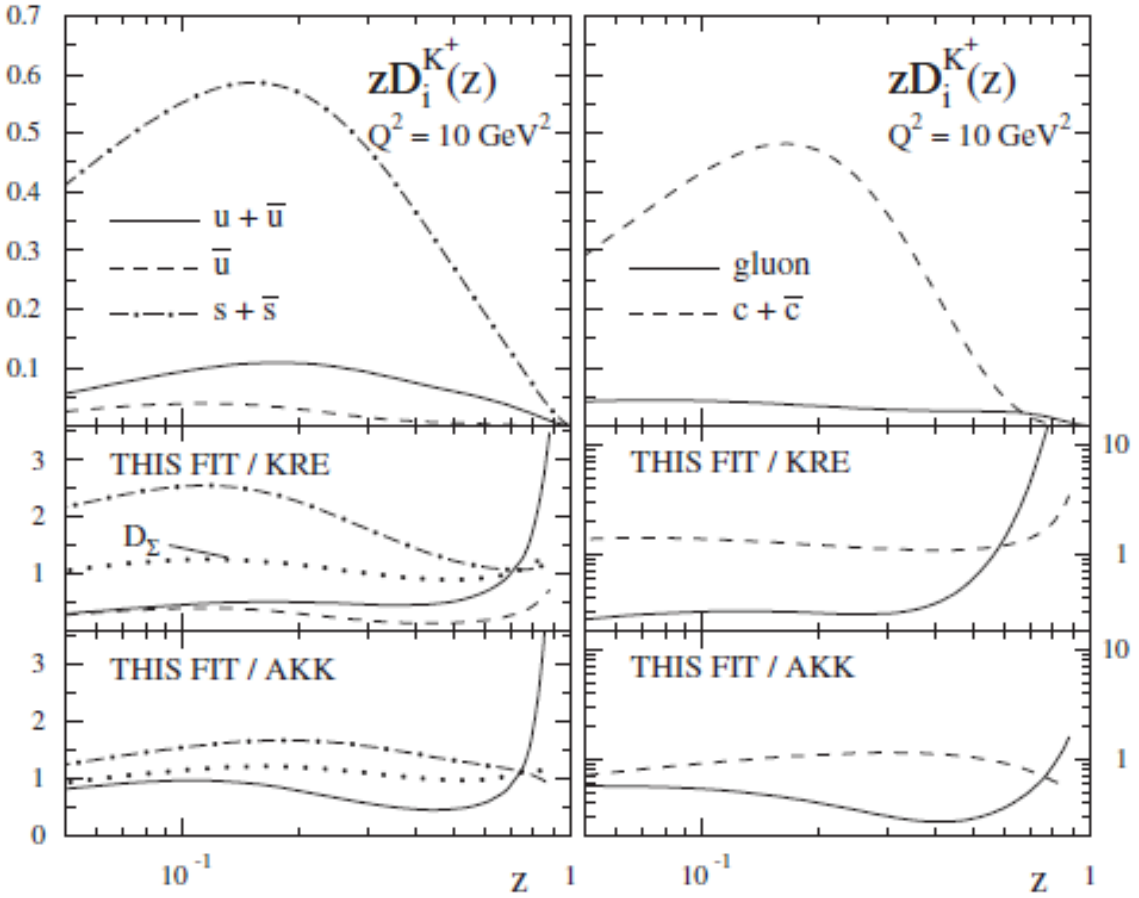
PLB 67 367 (1977)

- Lack of data at **low energy scale**
- PLUTO: about 35 years ago
  - Stat. uncertainty: 41%

PRD 75 114010 (2007)



- DSS @ HERMES Kaon production



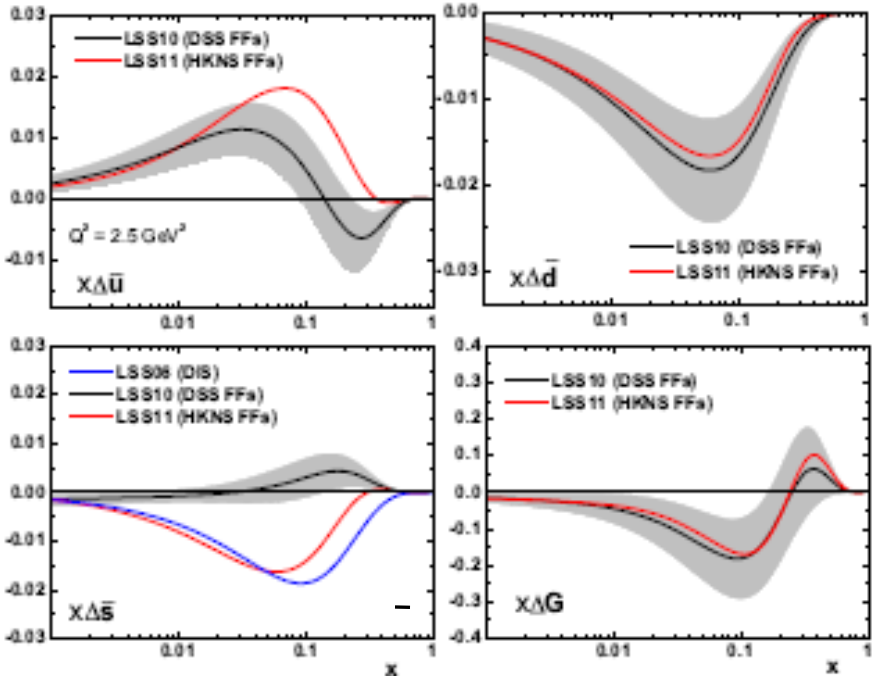
PRD 75 114010 (2007)

- Kaon FF @ DSS >> Kaon FF @ KRE & AKK
- Inclusive K_s production @ BESIII

Strange quark polarization puzzle

- sum of polarization strange parton PDFs: $\Delta s(x)+\Delta s(x)$
  - ➢polarized inclusive DIS: negative for all values of x
  - ➢Semi-inclusive DIS: positive for most of measured x

} **puzzle**

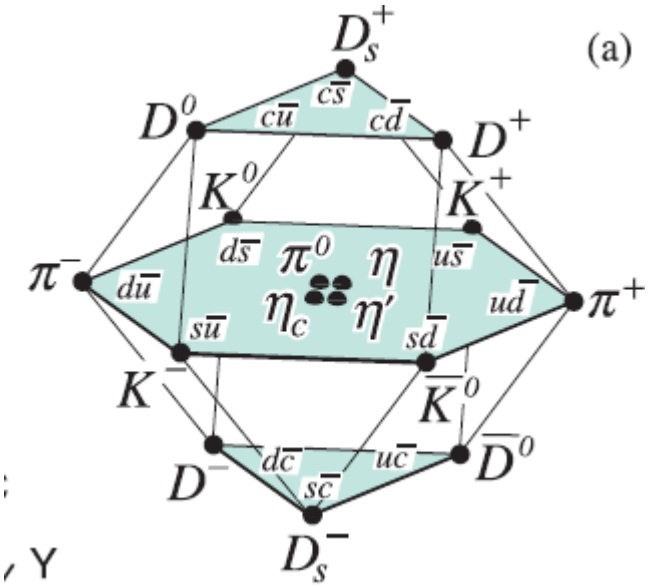


PRD 84 014002 (2011)

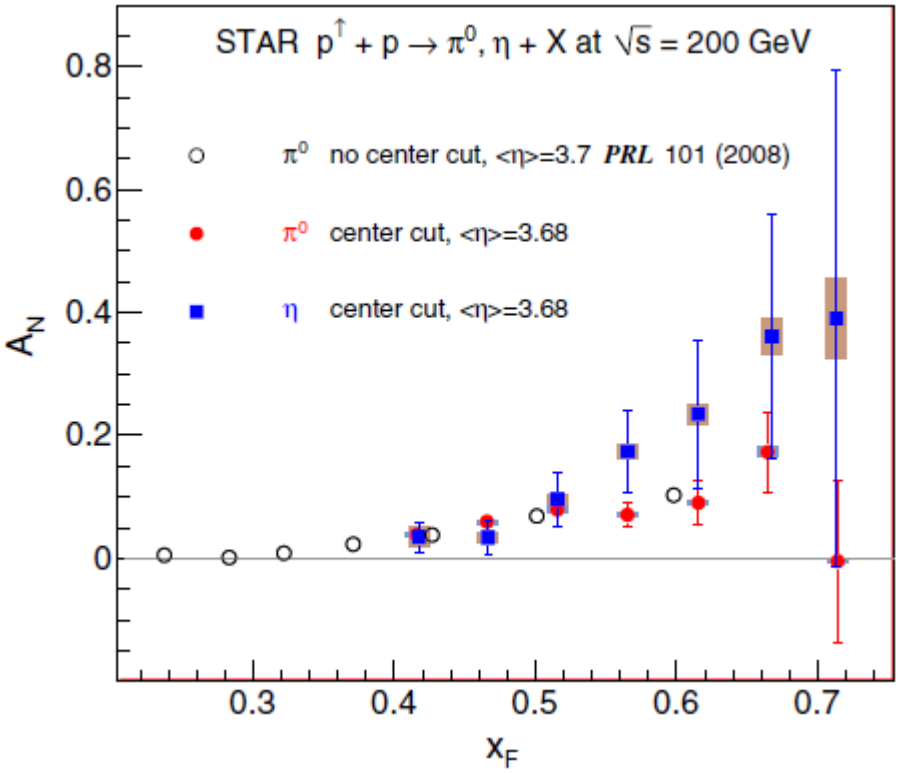
- Inclusive DIS: e+N→e'+X
  - ➢parton density function PDF
- Semi-inclusive DIS: e+N→e'+h+X
  - ➢PDF and FF

Inclusive kaon production

$e^+e^- \rightarrow \eta + X$



$|\eta> = |u\bar{u}+d\bar{d}-2s\bar{s}>$



PRD 86 051101(R) (2013)

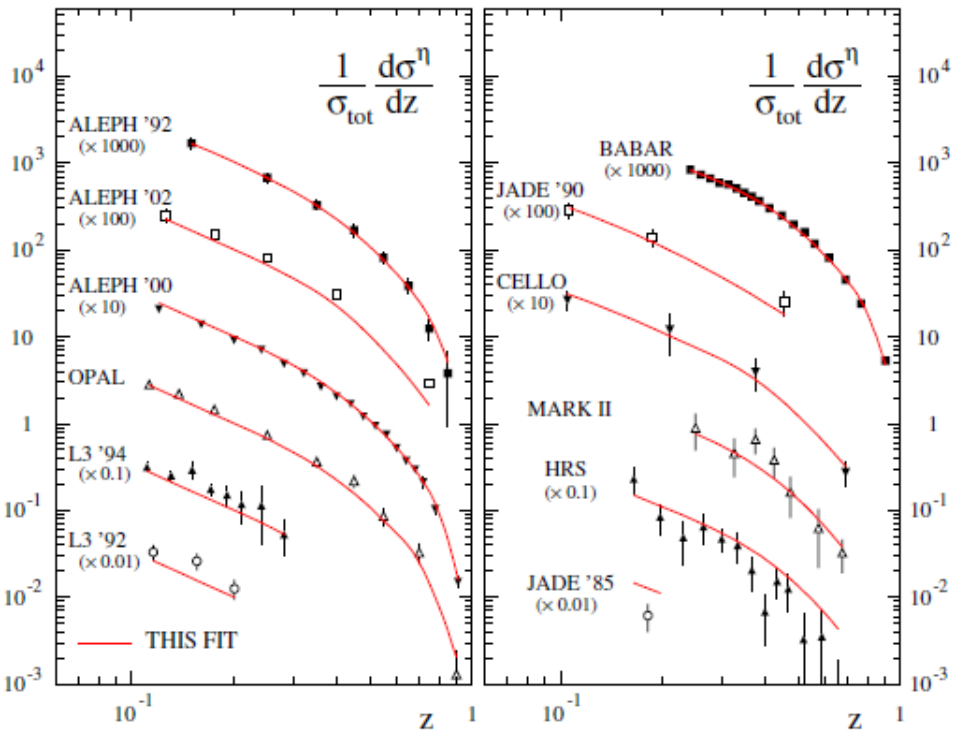
- Single spin asymmetry

$$A_N \equiv \frac{\sigma^\uparrow - \sigma^\downarrow}{\sigma^\uparrow + \sigma^\downarrow}.$$

- Understand eta FF

TABLE II. Data used in the global analysis of eta FFs, the individual χ^2 values for each set, and the total χ^2 of the fit.

Experiment	Data points fitted	χ^2
BABAR [36]	18	8.1
HRS [25]	13	51.6
MARK-II [26]	7	3.8
JADE '85 [27]	1	9.6
JADE '90 [28]	3	1.2
CELLO [29]	4	1.1
ALEPH '92 [30]	8	2.0
ALEPH '00 [31]	18	22.0
ALEPH '02 [32]	5	61.6
L3 '92 [33]	3	5.1
L3 '94 [34]	8	10.5
OPAL [35]	9	9.0
PHENIX 2γ [17]	12	4.1
PHENIX 3π [17]	6	2.9
PHENIX '06 [18]	25	13.3
TOTAL	140	205.9



PRD 83 034002 (2011)

- BESIII data @ [2.0 3.65]GeV**???**

$e^+e^- \rightarrow \phi + X$

- **$e^+e^- \rightarrow$ vector + x**

  Helicity density matrix of vector ρ_{mn}: **m/n=+1，0，-1**

- measure ρ_{00} via vector decay：θ of kaon at ϕ rest frame

$$\frac{dN}{d(\cos\theta^*)} = N_0 \times [(1-\rho_{00}) + (3\rho_{00}-1)\cos^2\theta^*]$$

- spin alignment： $\rho_{00} \neq 1/3$， ϕ production at BESIII???

TABLE III. Results for $\bar{\alpha}$ and $\rho_{\bar{0}0}$ found by various collaborations.

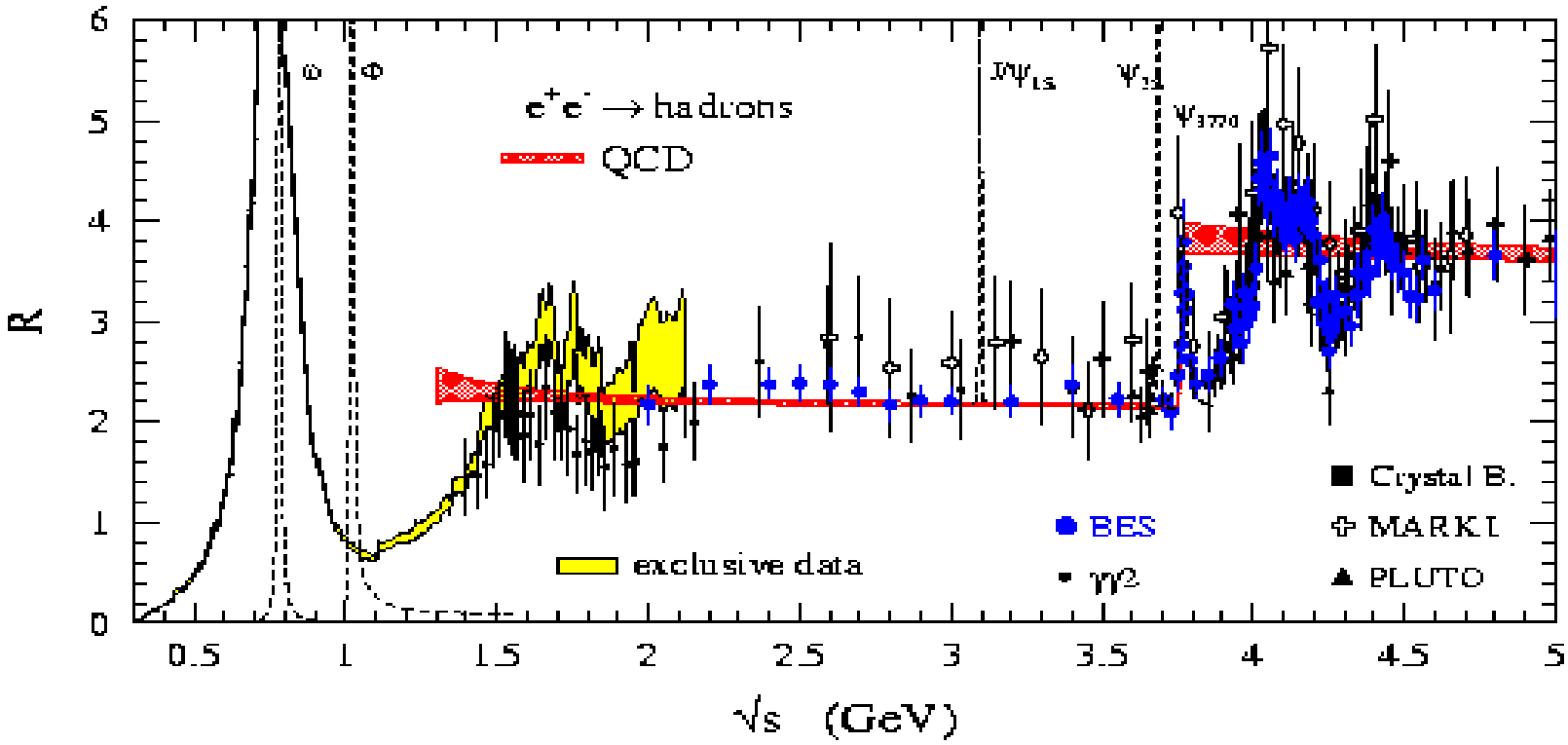
Collaboration	$\sqrt{s}$ (GeV)	$\bar{\alpha}$	$\bar{\rho}_{00}$
HRS	29	0.18±0.08	0.371±0.016
TPC	29	−0.14±0.17±0.03	0.301±0.042±0.007
SLD	91	0.019±0.378±0.582	0.34±0.08±0.13
OPAL	91	0.33±0.11	0.40±0.02
CLEO I.5	10.5	0.08±0.07±0.04	0.351±0.015±0.008
CLEO II	**10.5**	**−0.028±0.026**	**0.327±0.006**

PRD 58 052003 (1998)

Summary and outlook

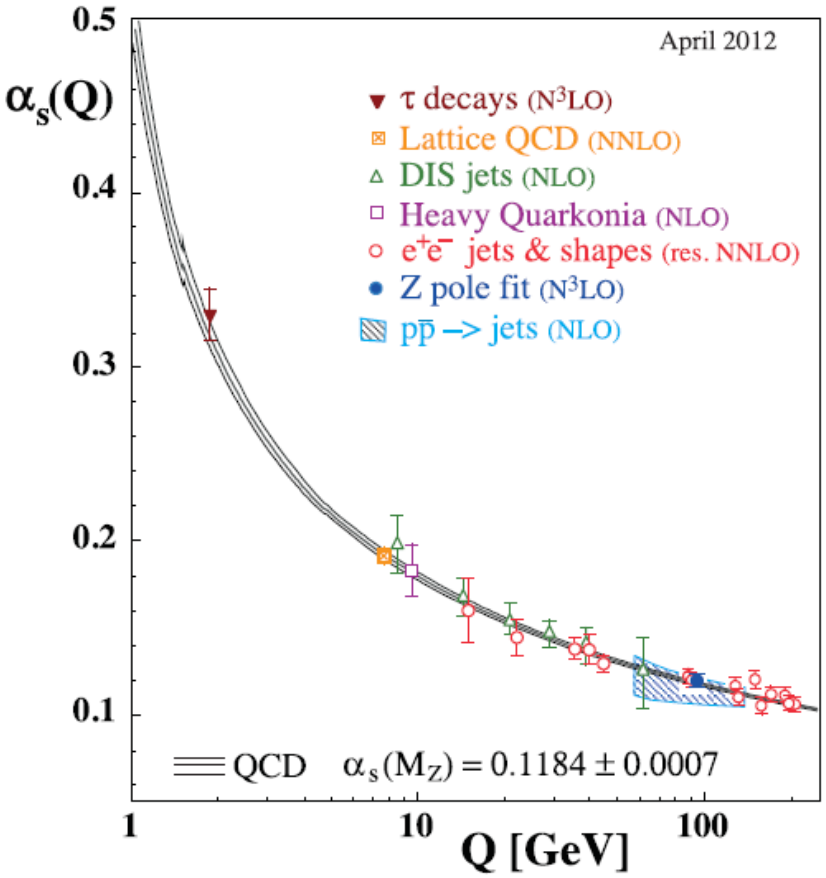
- Inclusive π^0/K_s production @ BESIII @ $\sqrt{s}$ **=[2.0, 3.65]GeV**, we could provide
  - data at at **low energy scale**
  - data **at high** $z=2E_{hadron}/\sqrt{s}$
- Inclusive η production, study of eta fragmentation function
- Inclusive ϕ production, spin alignment of vector ?
- Test MLLA/LPHD at low energy scale
- Constrain fragmentation function at low energy scale and high z

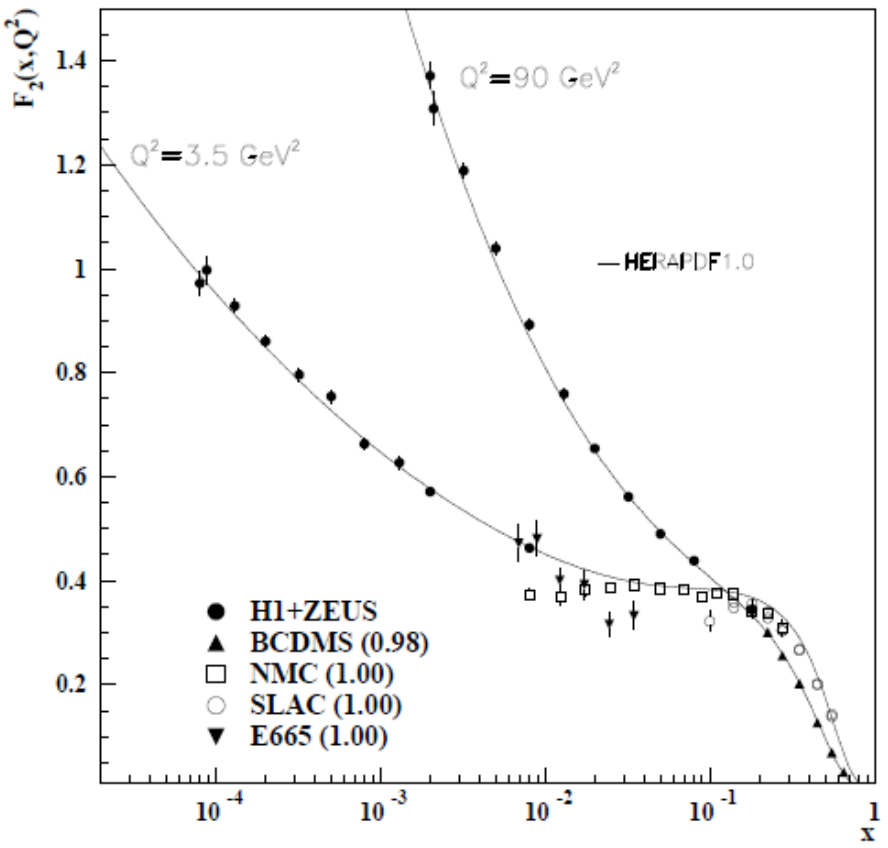
R(QCD) and R(BES)



- pQCD calculation agree amazingly well with BESII data.

α_s and F_2





PDG2012