STUDIES OF HADRONIC DECAYS OF Z^0 BOSONS AT SLD

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On behalf of

The SLD Collaboration

ICHEP2000, Osaka

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Paper 693: *Production of $\pi/K/p$ ...*

Paper 694: *Strange quark asymmetry*

Paper 695: *Hadron correlations*

MOTIVATION

- Poor understanding of hadronisation:
  at fundamental (QCD) level
  on a quantitative basis
- Models - JETSET, HERWIG, UCLA ...
  account for many (by no means all)
  of observed features
- b, c fragmentation rel. well understood:
  quark mass provides cutoff in pQCD
  one leading B, D hadron/jet
  $\rightarrow$ b, c jets easy to tag
- u, d, s fragmentation much less tractable:
  quark masses $\sim \Lambda_{QCD}$
  many leading (+ non-leading) π, K, p ...
  $\rightarrow$ u,d,s jets hard to tag: particle i.d.

SLD ADVANTAGES

- **Clean $Z^0 \to u\bar{u}$, $d\bar{d}$, $s\bar{s}$, $c\bar{c}$, $b\bar{b}$ events**

  updated results: 550k Z^0 (93-98)

- **VXD $\Rightarrow$ b / c / uds / g jet separation**

  ***eg.* # 'significant tracks' tag**

  Π **93 / 39 / 88 / 93 %**

  ϵ **57 / 62 / 85 / 12 %**

- **Polarised e^- beam $\Rightarrow$ $q/\bar{q}$ separation**

  Π **73%**

- **CRID $\Rightarrow$ $\pi^\pm$ / $K^\pm$ / $p^\pm$ separation**

  $0.5 < p < 35$ **GeV/c**

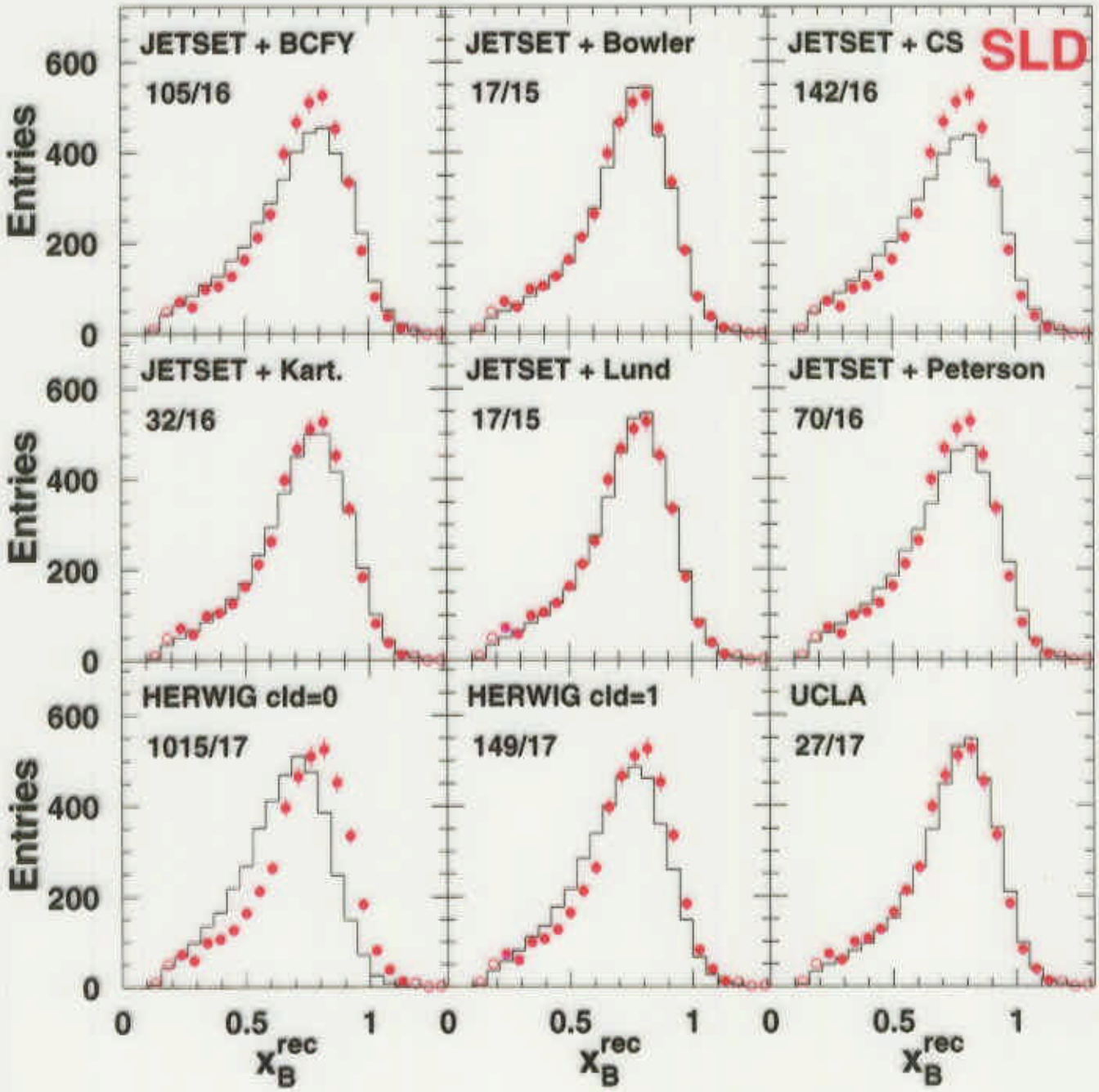
Measure: $\pi^\pm$, $K^\pm$, $p^\pm$, K^0, K^{*0}, ϕ, Λ

in: b, c, uds, g **jets**

and in: quark vs. antiquark jets

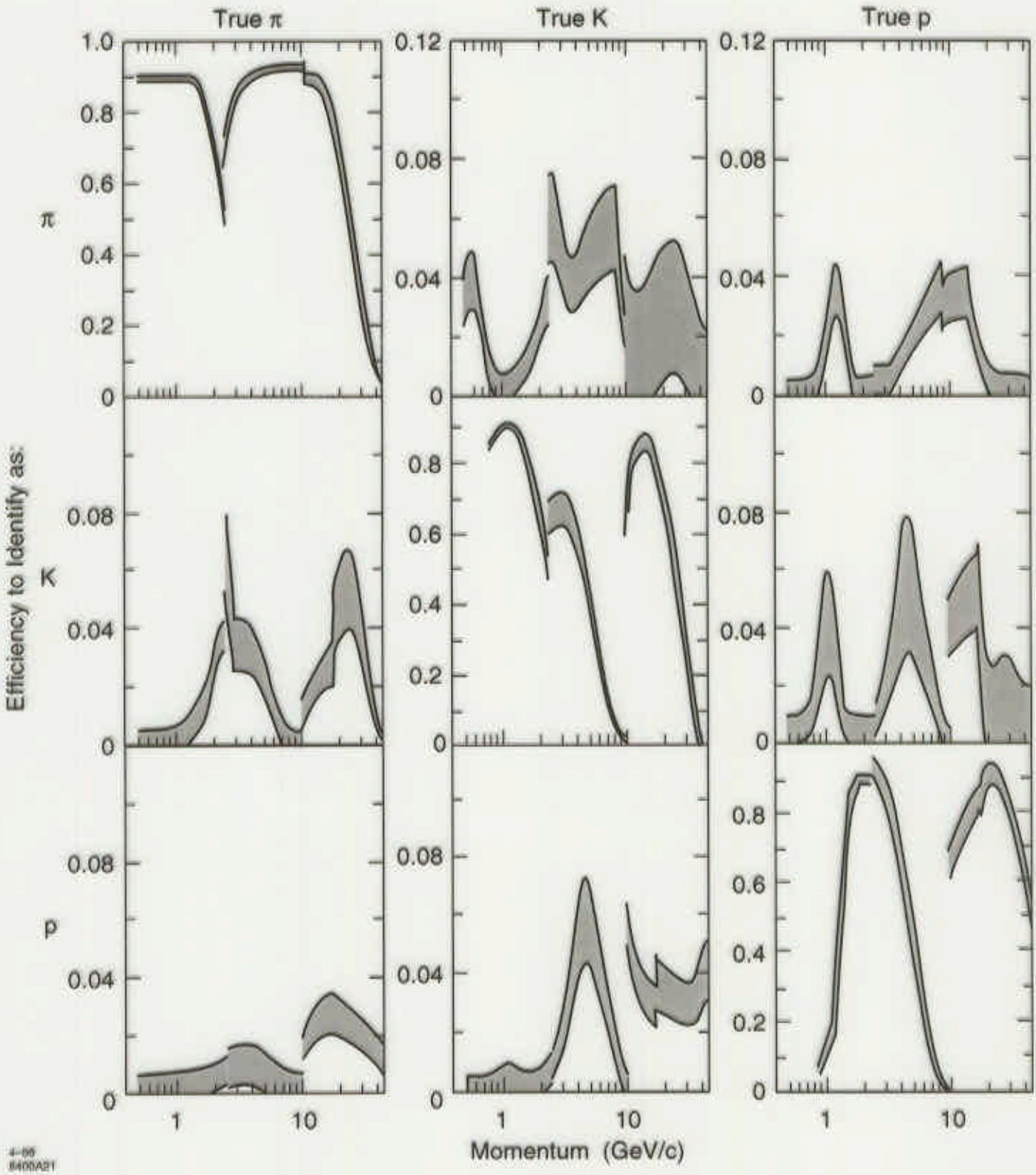
b FRAGMENTATION FUNCTION

B ENERGY FROM DECAY-VERTEX RECONSTRUCTION



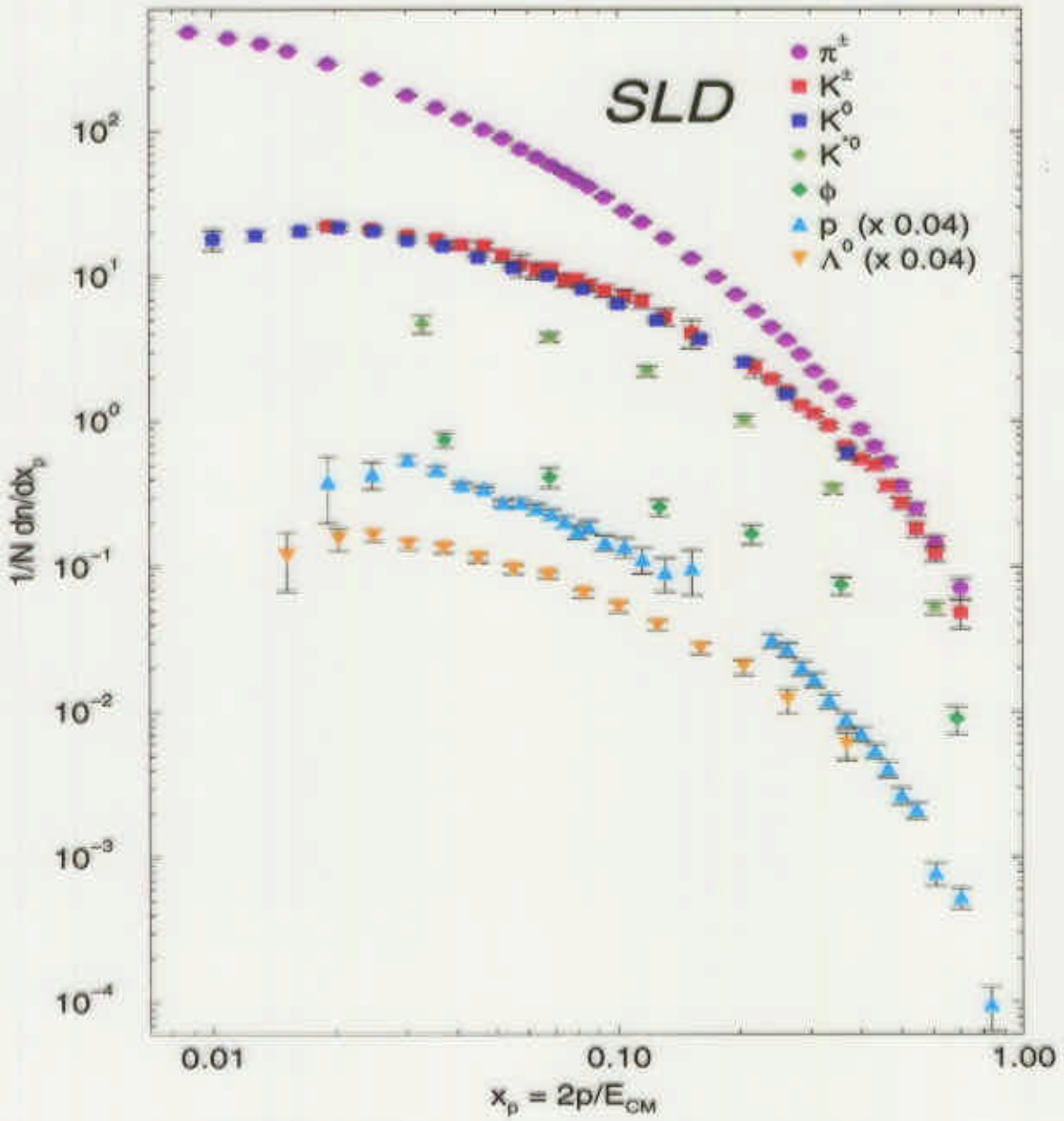
[Phys. Rev. Lett 84 4300 (2000); ICHEP: 690]

MEASURED SHAPE EXCLUDES MANY MODELS


True π
True K
True p
Efficiency to Identify as:
π
K
p
Momentum (GeV/c)
1
10
4-86
8400A21

LIGHT HADRON PRODUCTION

IN JETS OF INCLUSIVE FLAVOUR

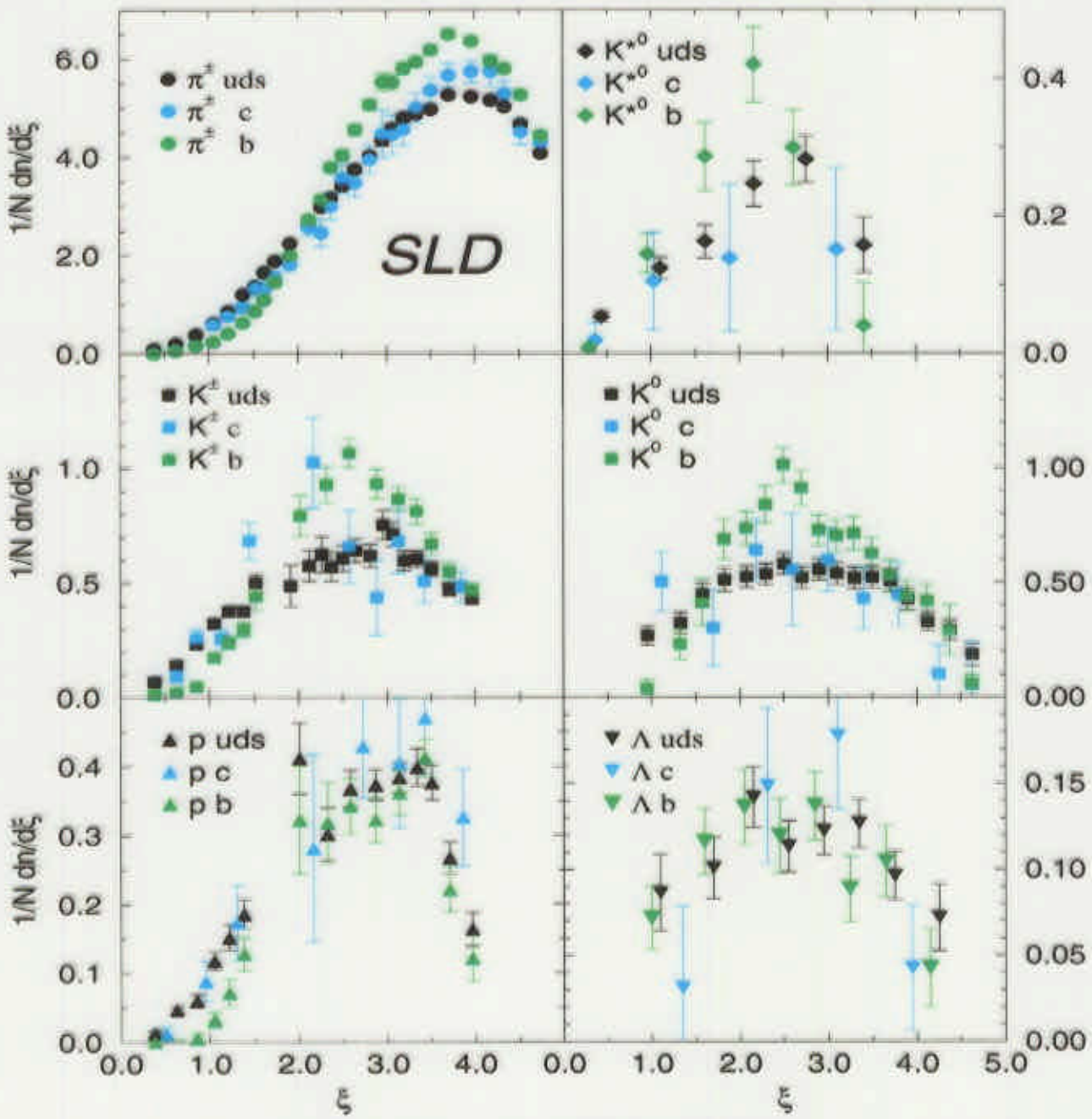


[Phys. Rev. D59 052001 (1999)]

COMPLETE KINEMATIC COVERAGE: $0.01 < x_p < 0.8$

$\xi = -\ln(1/x_p)$ DISTRIBUTIONS

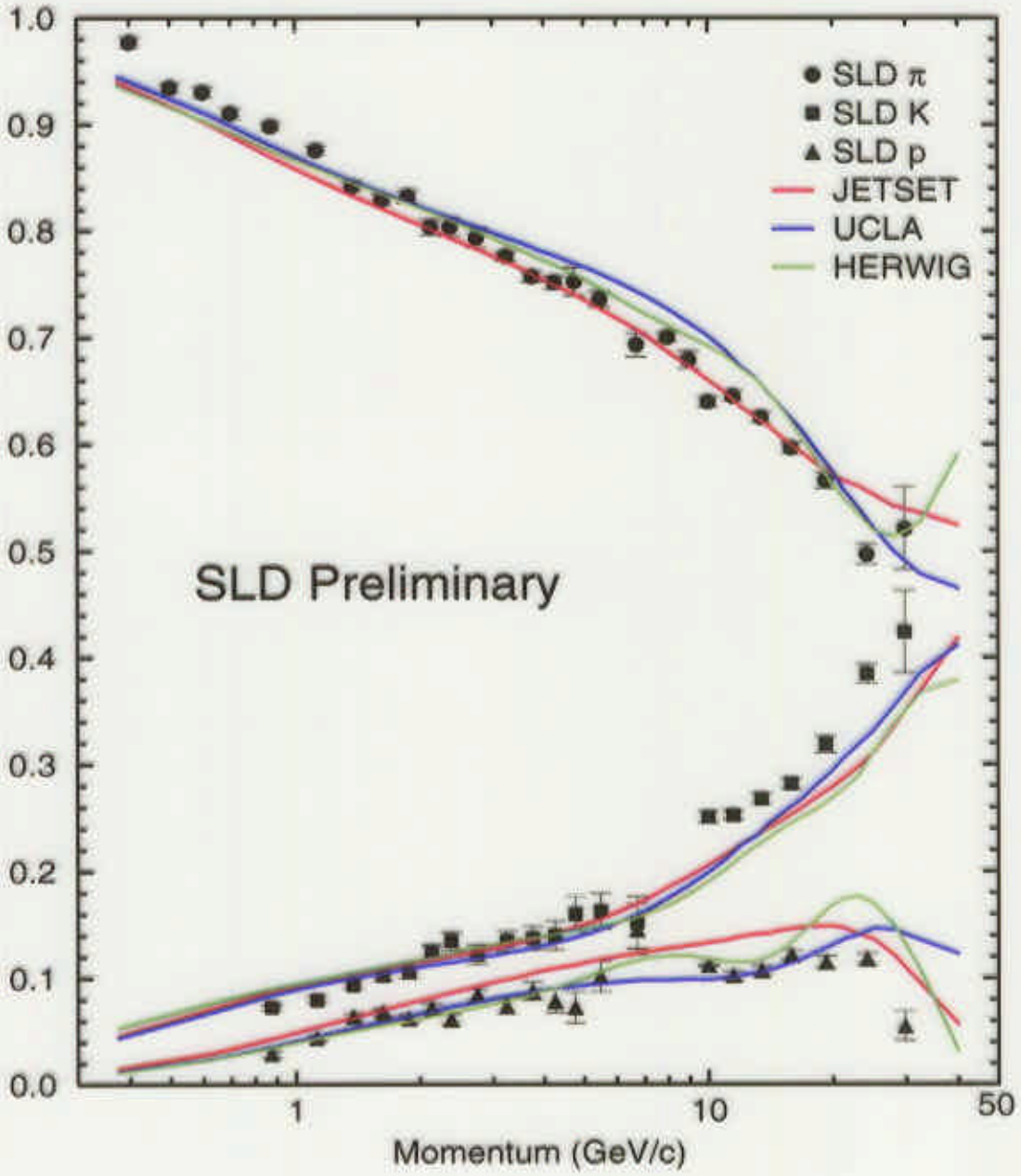
IN b, c, uds JETS



[Phys. Rev. D59 052001 (1999)]

CLEAR FLAVOUR DEPENDENCE: FIT SEPARATELY

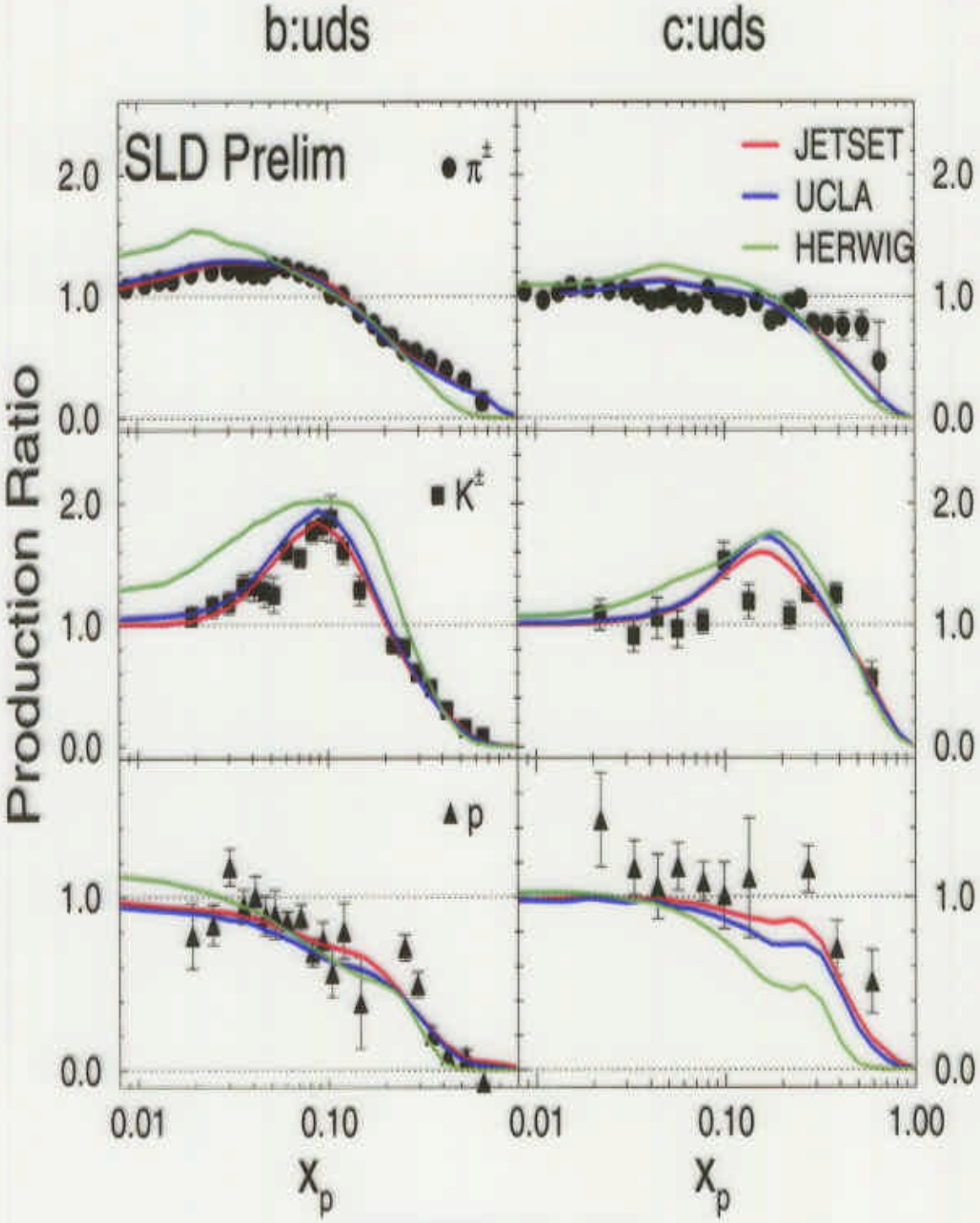
p-DEPENDENCE OF π, K, p FRACTIONS IN uds JETS vs. FRAGMENTATION MODELS



[ICHEP2000: 693]

NO MODEL REPRODUCES p DEPENDENCE

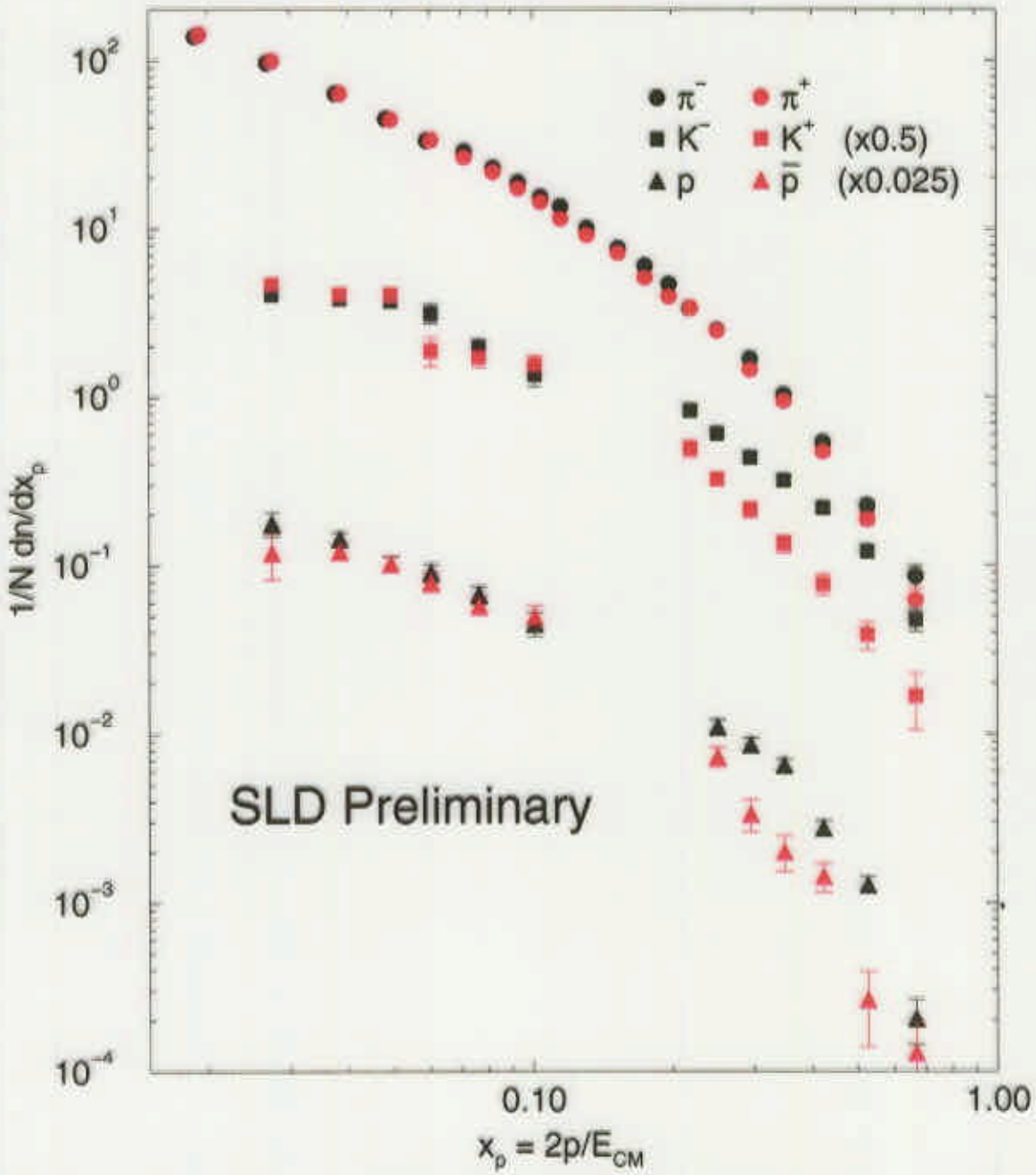
FLAVOUR-DEPENDENCE OF π, K, p PRODUCTION



[ICHEP2000: 693]

HERWIG HAS TROUBLE WITH B FRAG/DECAY

HADRON VS. ANTIHADRON PRODUCTION IN LIGHT **QUARK** JETS

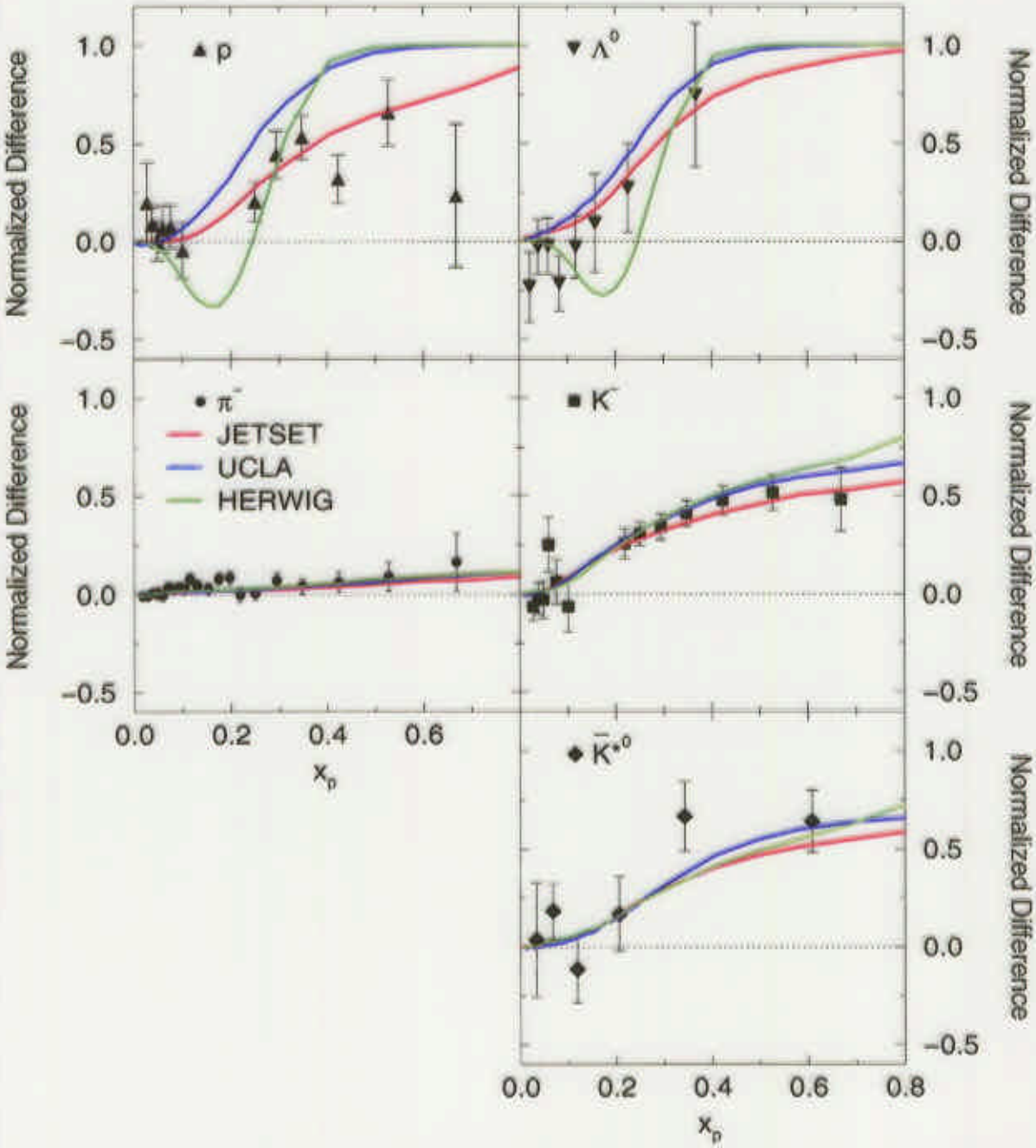


[ICHEP2000: 693]

STRONG LEADING-PARTICLE EFFECT

LEADING-PARTICLE EFFECT

vs. FRAGMENTATION MODELS

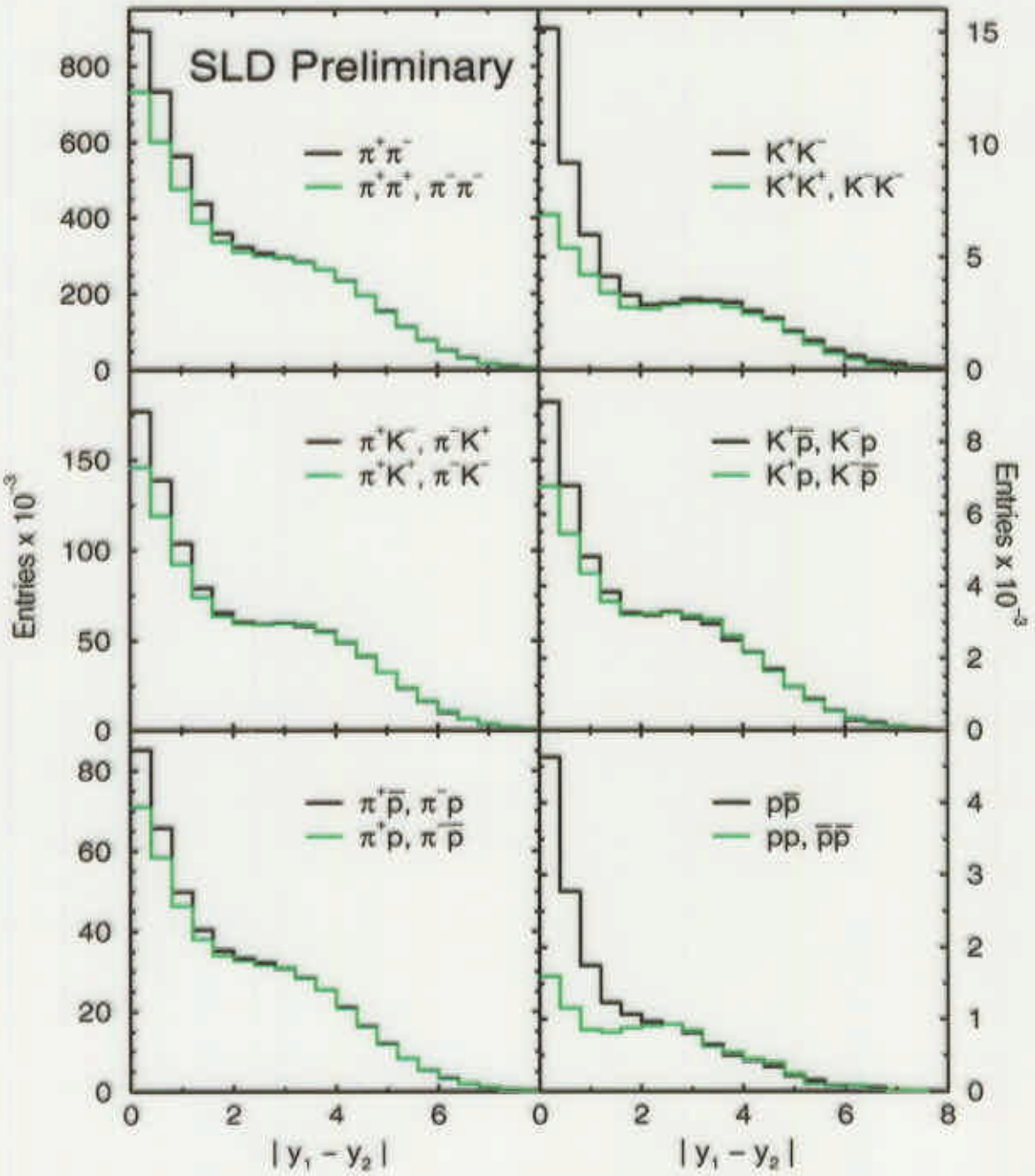


[ICHEP2000: 693]

MODELS IN QUALITATIVE AGREEMENT

RAPIDITY DIFFERENCE

BETWEEN PAIRS OF HADRON SPECIES

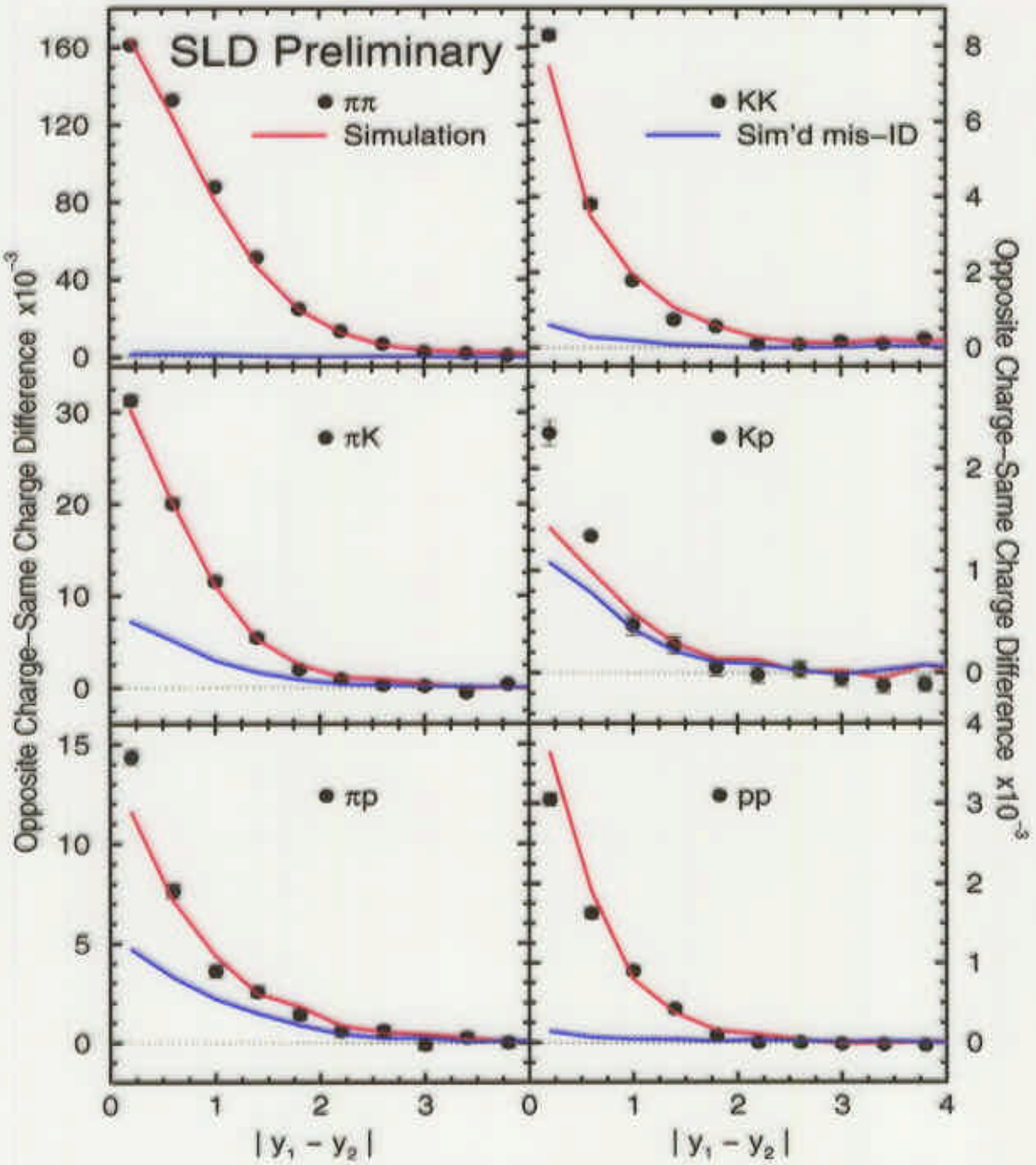


[ICHEP2000: 695]

OPPOSITE-SIGN EXCESS AT SMALL RAP. DIFF.

OPPOSITE-CHARGE EXCESS

vs. JETSET SIMULATION

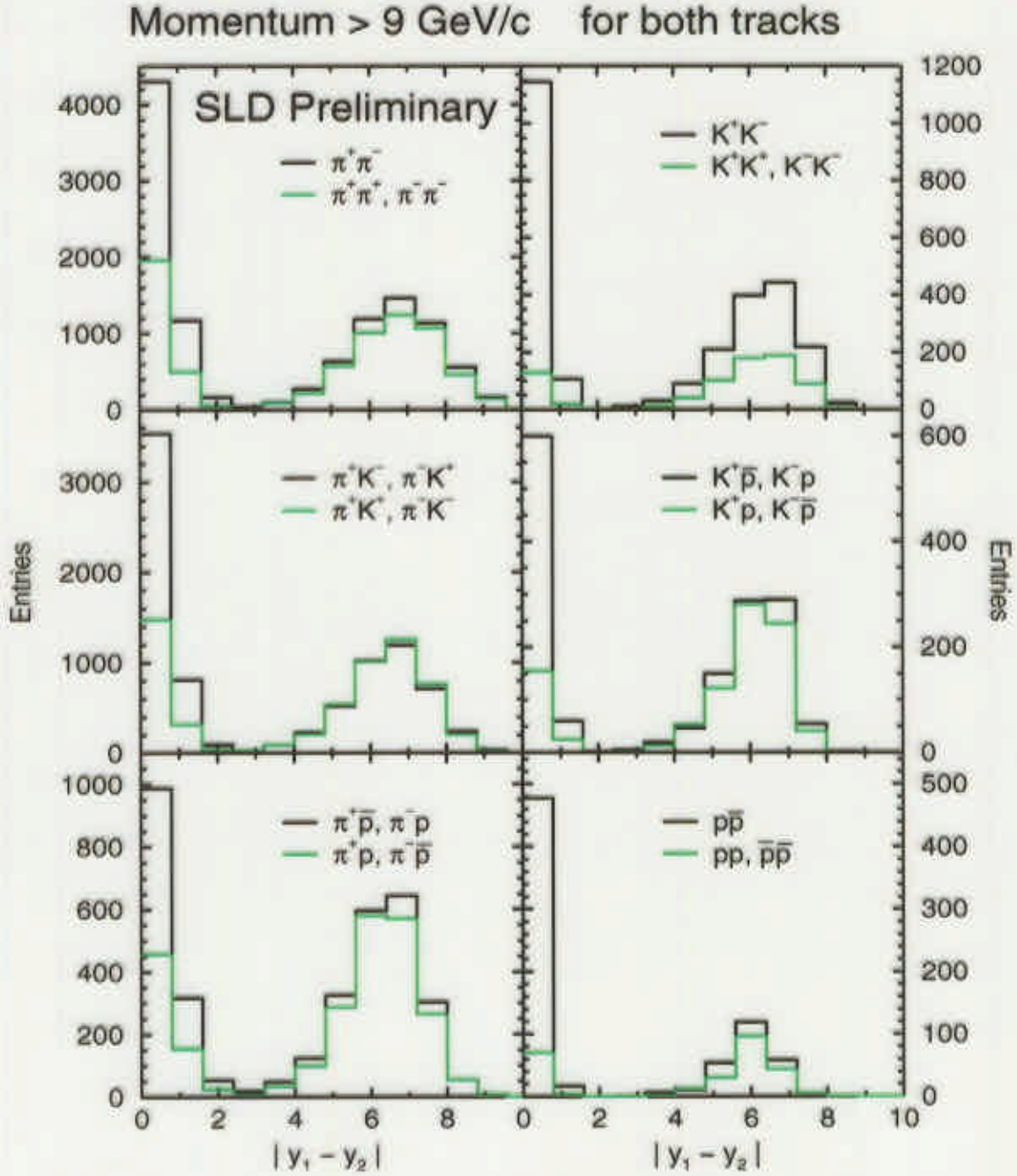


[ICHEP2000: 695]

SHORT-RANGE CHARGE, BARYON # COMPENSATION

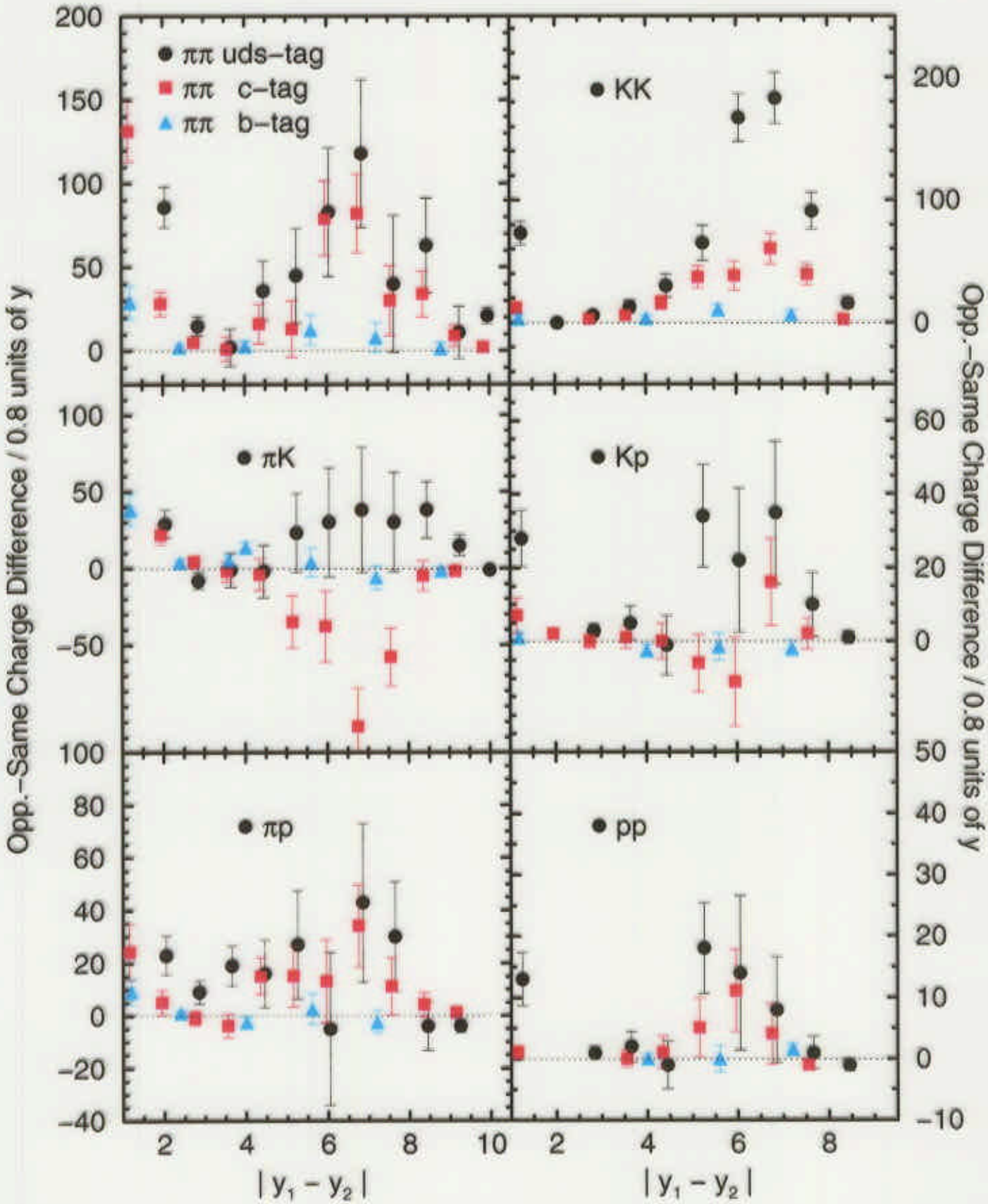
RAPIDITY DIFFERENCE

FOR HIGH-MOMENTUM TRACKS



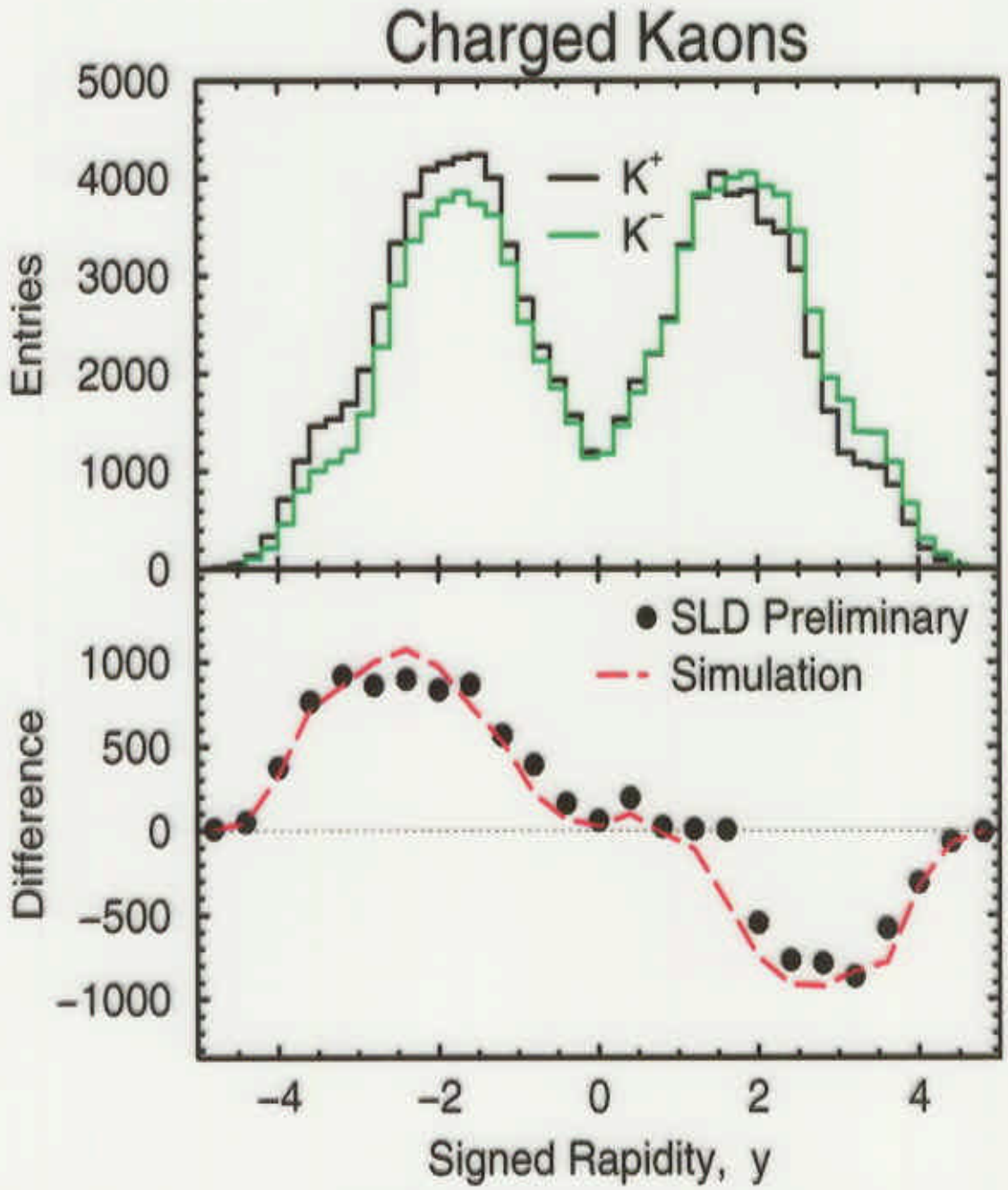
[ICHEP2000: 695]

LONG-RANGE CHGE. COMPENSN: LEADING PARTS.


ππ uds–tag
ππ c–tag
ππ b–tag
KK
πK
Kp
πp
pp
Opp.–Same Charge Difference / 0.8 units of y
Opp.–Same Charge Difference / 0.8 units of y
| y1 – y2 |
| y1 – y2 |

SIGNED RAPIDITY

THRUST AXIS POINTS IN 'QUARK' DIRECTION



[ICHEP2000: 695]

DIRECT INDICATION OF LEADING KAONS

STRANGE-QUARK ASYMMETRY

- Use LEADING-PARTICLE EFFECT in $Z^0 \to s\bar{s}$ events to measure EW coupling $A_s \equiv 2v_s a_s/(v_s^2 + a_s^2)$ using s-quark polar-angle aymmetry:

$$\frac{d\sigma}{d\cos\theta} \propto 1 + \cos^2\theta_s - 2P_Z A_s \cos\theta_s$$

- Veto $c\bar{c}$, $b\bar{b}$ events: $n_{sig} < 2$

- Tag $s\bar{s}$ events by requiring:
  1 high-momentum $K^\pm$ ($p > 9$ GeV), K^0_s ($p > 5$ GeV)
  of unequal strangeness in each hemisphere

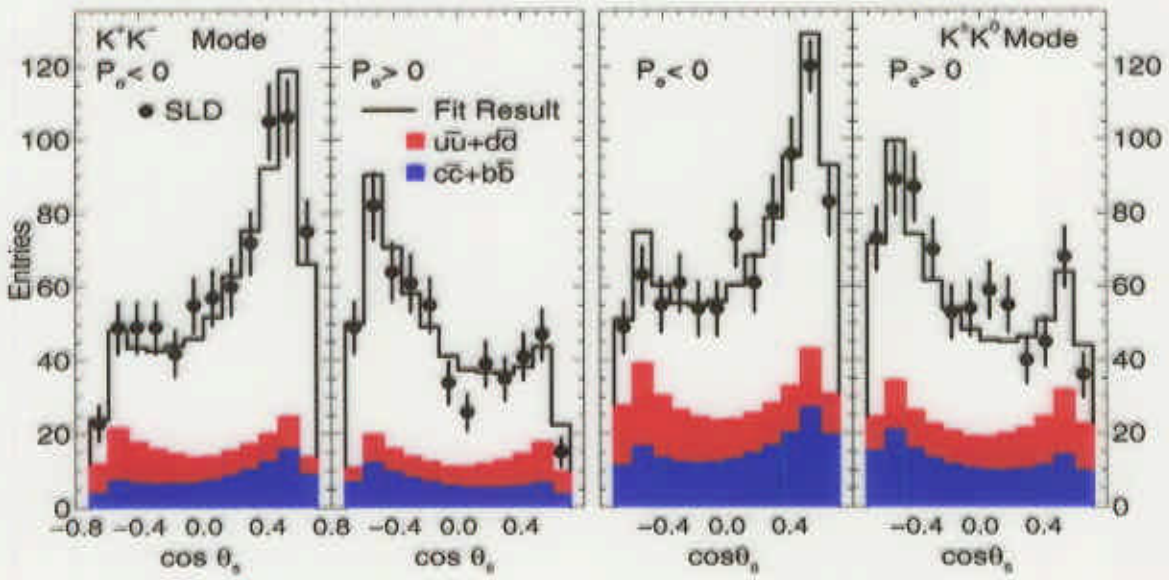
- $\cos\theta_s = \cos\theta_{thrust}$ pointing into K^- hemisphere

- Unbinned max. likelihood fit to extract A_s

Mode	# Events in Data	MC Prediction	$s\bar{s}$ Purity	Analyzing Power
K^+K^-	1290	1312	0.73	0.95
$K^\pm K^0_s$	1580	1617	0.60	0.70

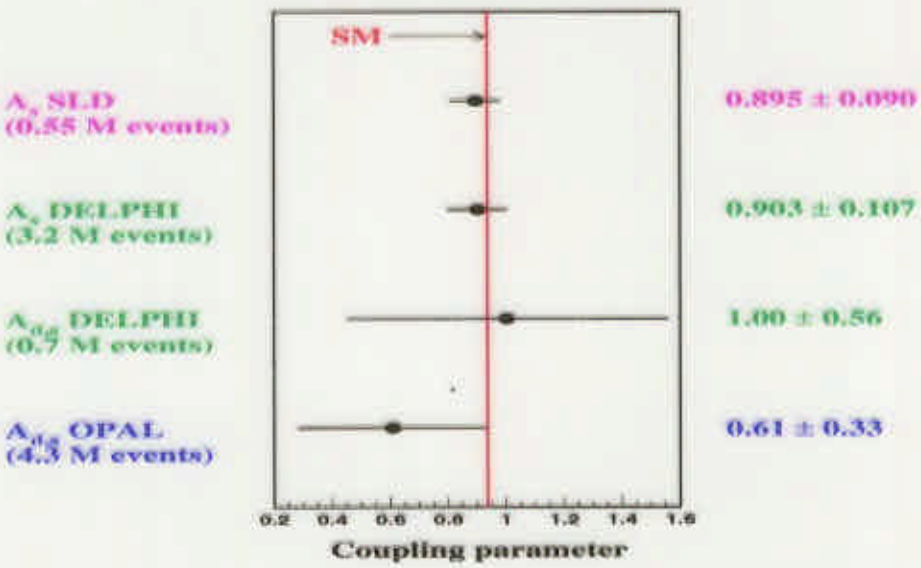
- Sample composition: 66% $s\bar{s}$, 16% $c\bar{c}$, 1% $b\bar{b}$, 9% $u\bar{u}$, 8% $d\bar{d}$

STRANGE-QUARK ASYMMETRY



$$A_s = 0.895 \pm 0.066(stat.) \pm 0.062(syst.)$$

[SLAC-PUB-8408; subm. to PRL; ICHEP2000: 694]



8% test of d-type coupling universality

SUMMARY + CONCLUSIONS

- **SLD using flavour tagging capabilities:**
  - **unique 307M pixel CCD VXD $\Rightarrow b/c/uds/g$ jet i.d.**
  - **Cerenkov detector: π/K/p i.d. and $s\bar{s}$ event i.d.**
  - **unique polarized electron beam $\Rightarrow q$ vs $\bar{q}$ jet i.d.**

  $\Rightarrow$ incisive new tests of jet fragmentation

- **Measured identified hadron fragmentation functions:**
  - **in jets of different primary flavour**
  - **in quark vs. antiquark jets**

  $\Rightarrow$ dramatic differences in properties

- **Defined new observables:**
  - **hadron/antihadron asymmetry**
  - **(charge-ordered) correlations in signed rapidity**

  $\Rightarrow$ leading-particle effects in light-quark fragmentation

- **Provide new challenges to jet fragmentation models!**

- **Measured s-quark polar-angle asymmetry**

  $\Rightarrow$ direct (most precise) determination of coupling A_s