Tuning of the LUND Model for Fragmentation Functions and Purities

A. Hillenbrand
Physikalisches Institut, Universität Erlangen-Nürnberg,
91058 Erlangen, Germany

for the HERMES collaboration

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- ▷ Motivation
- ▷ Multiplicities from experimental data
- ▷ Tuning the LUND fragmentation model to HERMES energies
- ▷ Comments about target fragmentation in the LUND model
- ▷ Conclusion & Outlook

Introduction

HERMES 2000 unpol. Proton data:

multiplicities $\pi^\pm$, $\mathrm{K}^\pm$ and (anti-)protons vs. z, p_t and p

↓

Tuning of the LUND fragmentation model to HERMES energies

↓

charge & flavor separated FF

$D_u^{\pi^+}, D_u^{\pi^-}, D_u^{\mathrm{K}^+}, D_u^{\mathrm{K}^-} \ldots$

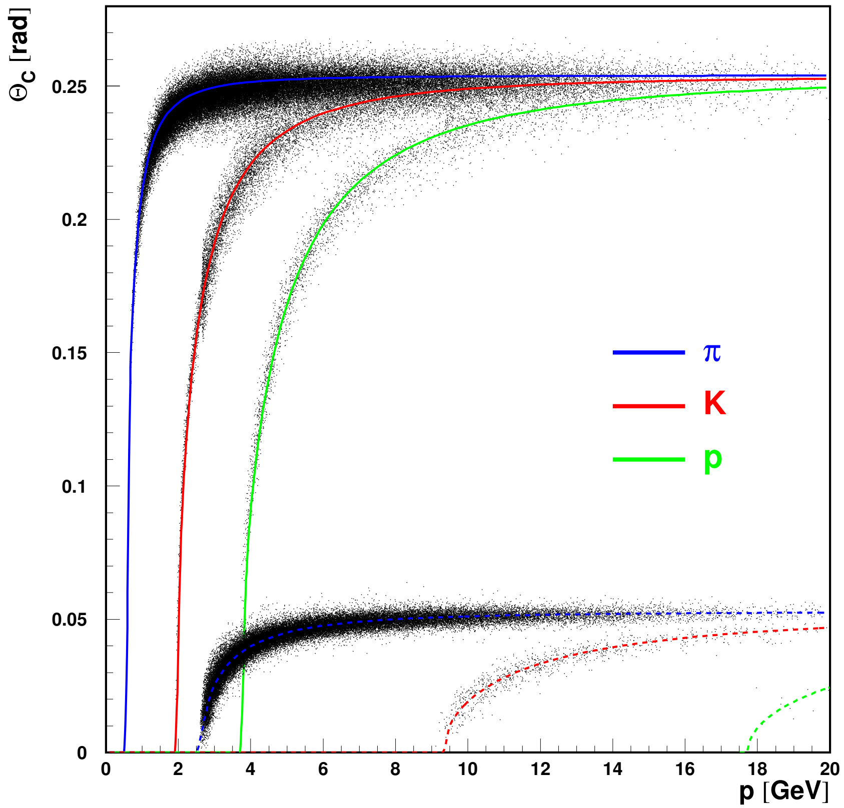
→

reduce systematic errors on the (Kaon-)Purities

RICH detector

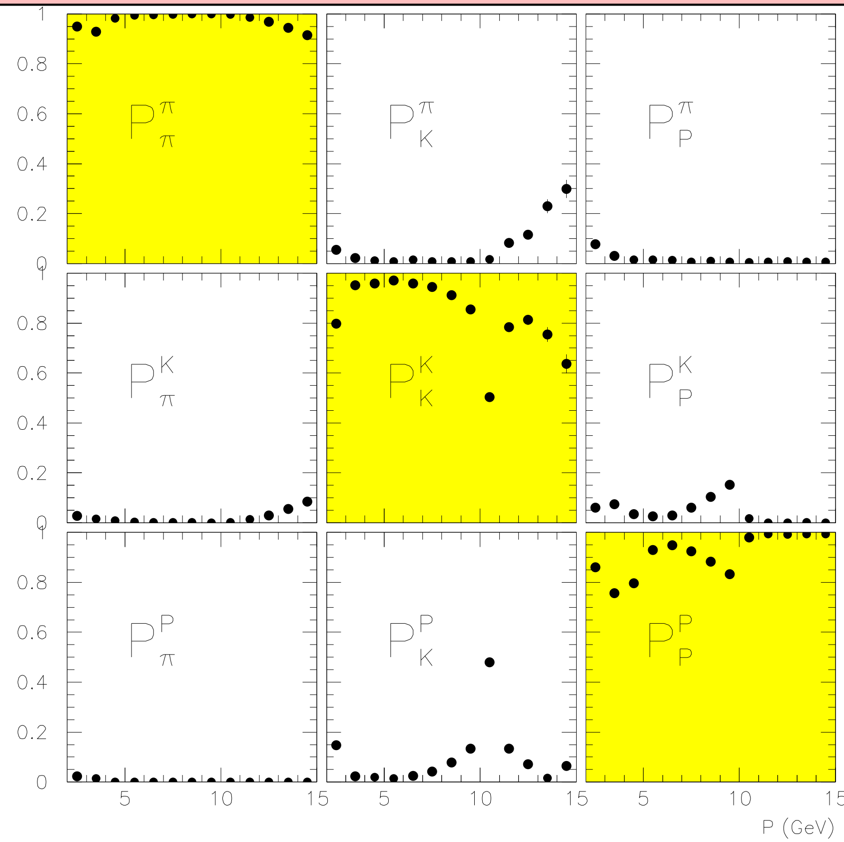
RICH - Čerenkov angle

2 Radiators: Aerogel
C_4F_{10}



Probability matrix P

$P_t^i =$ Probability that a particle of true type t will be identified as a particle of type i



Multiplicities from Experimental Data

Multiplicity:

$$m_i = \frac{N_{h,i}}{N_{\text{DIS}} \cdot d_{\text{bin}}} = \frac{1}{\sigma_{\text{DIS}}} \cdot \frac{d\sigma^h(x)}{dx}$$

with

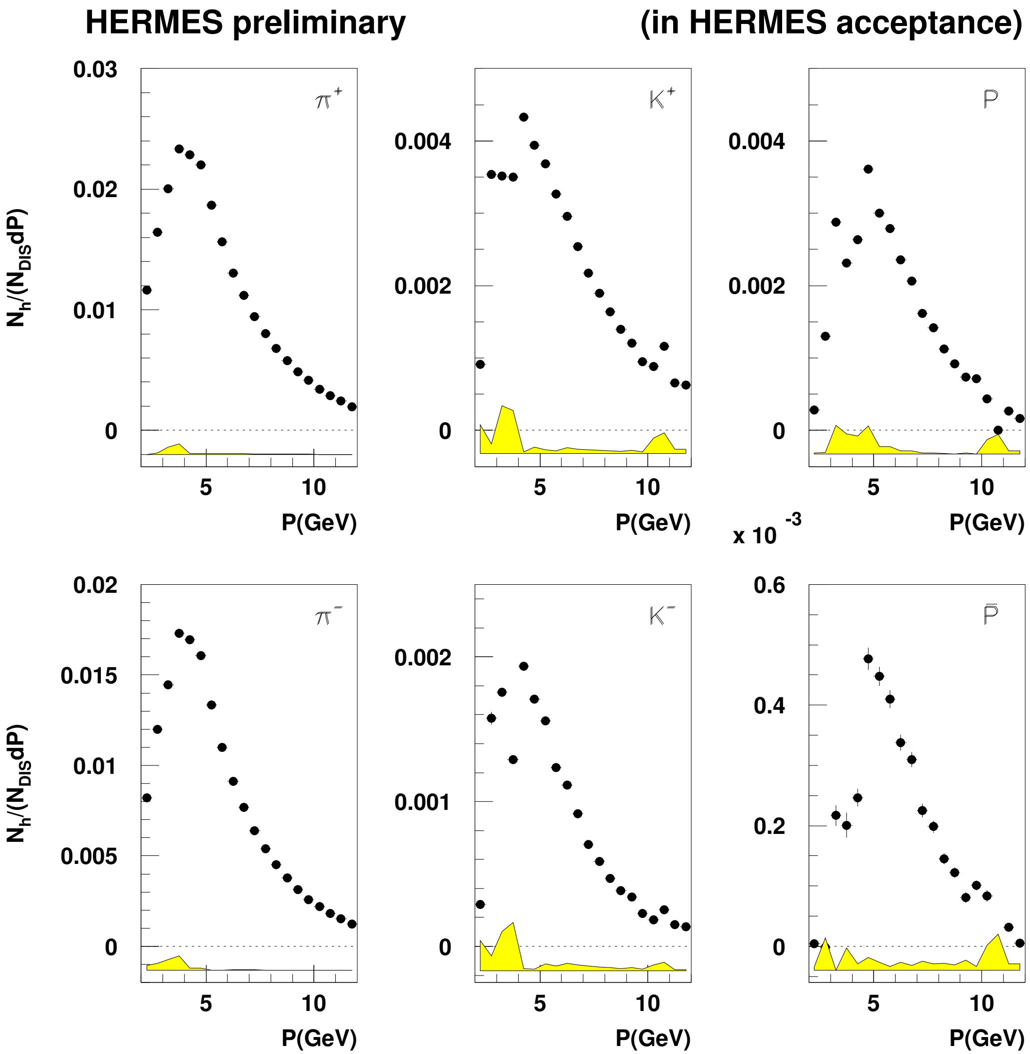
- $N_{h,i}$: Number of 'true' hadrons h in bin i
- N_{DIS} : Total number of accepted DIS events
- d_{bin} : bin width

Statistics (in Mio.):

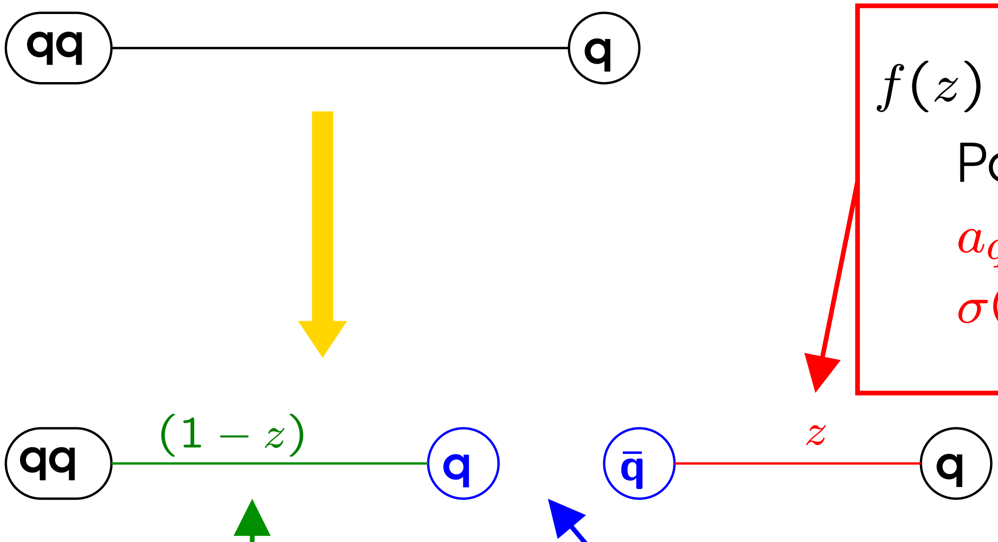
Events	Pions	Kaons	Protons
6.1	2.1	0.25	0.19

Cuts: $Q^2 > 1\,\text{GeV}^2$ $W^2 > 10\,\text{GeV}^2$

$z = \frac{E_h}{E-E'} > 0.2$ $x_{\text{F}} > 0.1$



The LUND string fragmentation model



$f(z) \sim (1-z)^{a}/z \cdot e^{-b\cdot(m_h^2+p_T^2)/z}$

Parameter: a(PJ41), b(PJ42)

a_{qq}(PJ45) ($\rightarrow$ di-quarks)

σ(PJ21): width of Gaussian p_T

E_0(PJ33): energy cut-off parameter

PJ2: s-quark suppression

PJ1,3: di-quark suppression

PJ11,12: VM-suppression

LUND tuning overview

- 'Hand-tune' several parameters by parameter scans

VM suppression (PJ11)	$\Rightarrow$	$\frac{\pi^0}{\rho^0}$
strange VM suppression (PJ12)	$\Rightarrow$	$\frac{K^0}{K^{*0}}$ and Φ
di-quark suppression (PJ1)	$\Rightarrow$	$\bar{P}$-multiplicities
strange di-quark suppression (PJ3)	$\Rightarrow$	$\bar{\Lambda}$
strange quark suppression (PJ2)	$\Rightarrow$	K-multiplicities
a_{qq}(PJ45)	$\Rightarrow$	P-multiplicities

- Example: Tuning of PJ11 to $\frac{\pi^0}{\rho^0}$-ratio

	Data	MC (PJ11=...)			
		0.1	0.2	0.5	0.9
Ratio	15.4	20.4	15.2	5.2	2.8

- Iterative tuning of the remaining parameters:

a(PJ41), b(PJ42), σ(PJ21)

Goal:

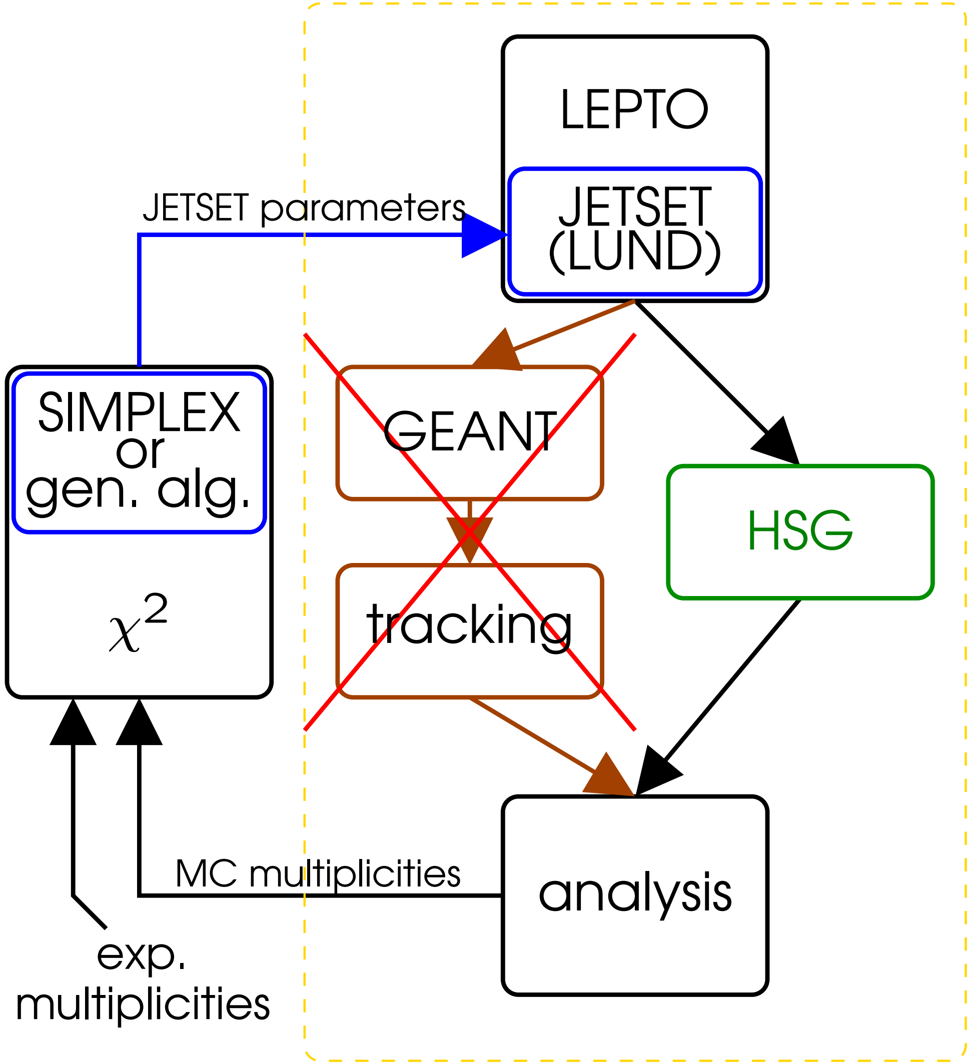
$$\text{minimize} \quad \chi^2_{\text{tot}} = \frac{\sum_a \chi^2_a}{\sum_a n_a}$$

where

$$\chi^2_a = \sum_i \frac{\left(m_{\text{Data},i} - m_{\text{MC},i}\right)^2}{\sigma^2_{m_{\text{Data},i}} + \sigma^2_{m_{\text{MC},i}}}$$

using the multiplicities $\pi^{\pm}$, K$^{\pm}$ and (anti-)protons vs. z, p_{t} and p

Modeling of detector effects



Statistics/Iteration: $\sim$ 2 million

Full tracking: Time/Iteration $\sim$ 20 days[a]

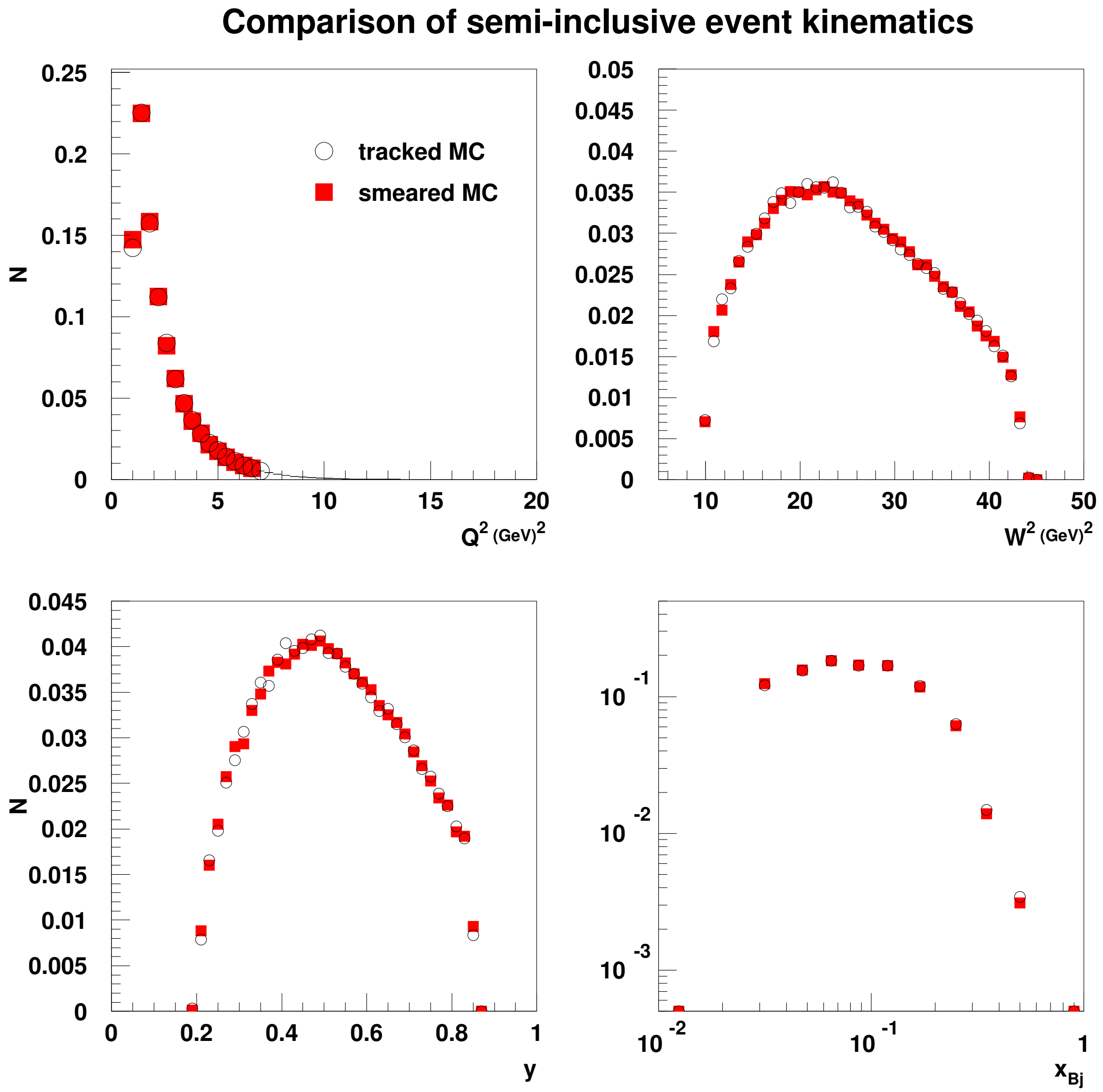
$\Rightarrow$ alternative approach needed to account for detector smearing

HERMES Smearing generator: applies effects due to detector smearing etc. on a statistical basis.

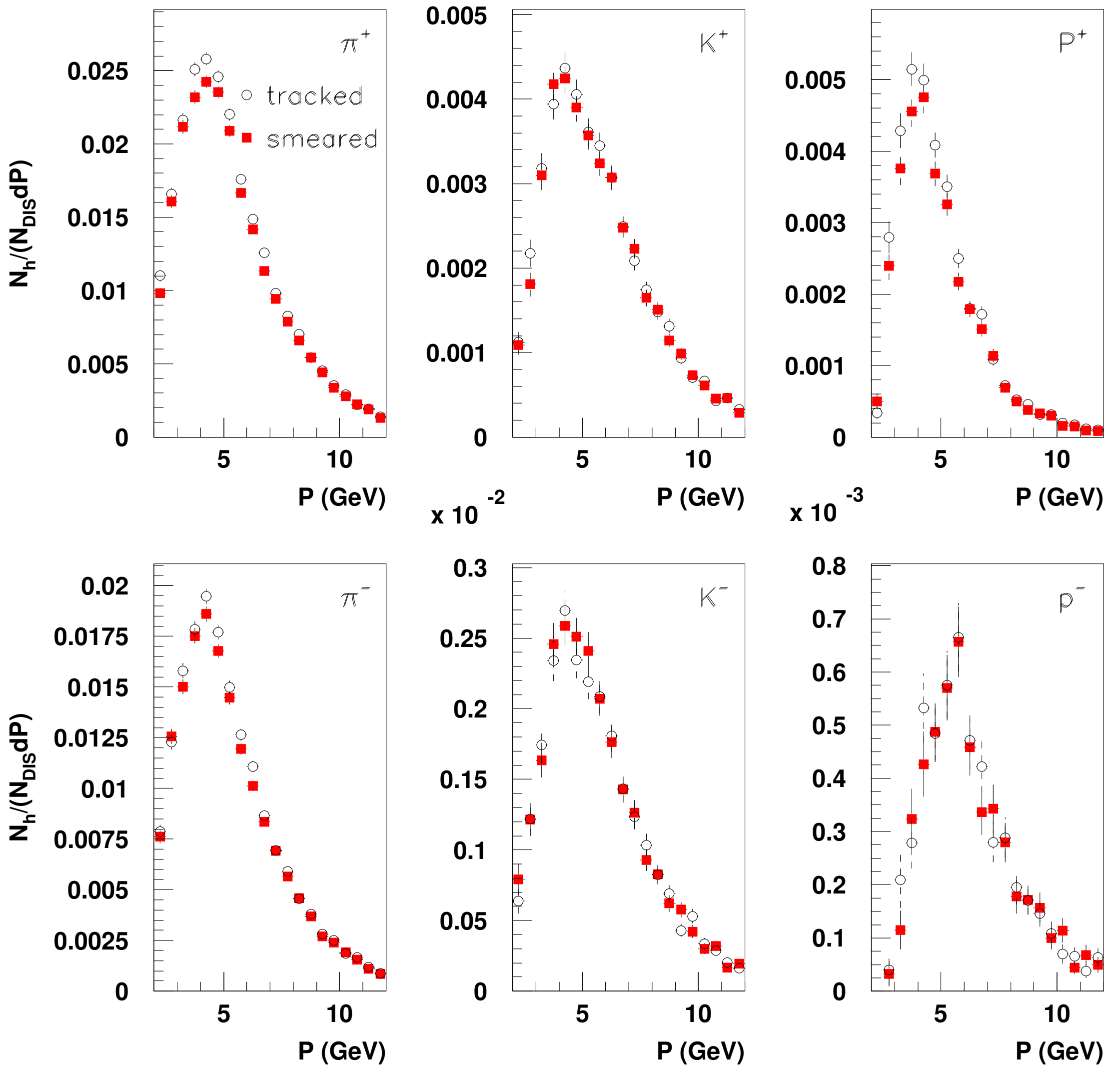
$\Rightarrow$ Time/Iteration $\sim$ 100 minutes

[a]for 1 standard PC CPU($\sim$1.5 GHz)

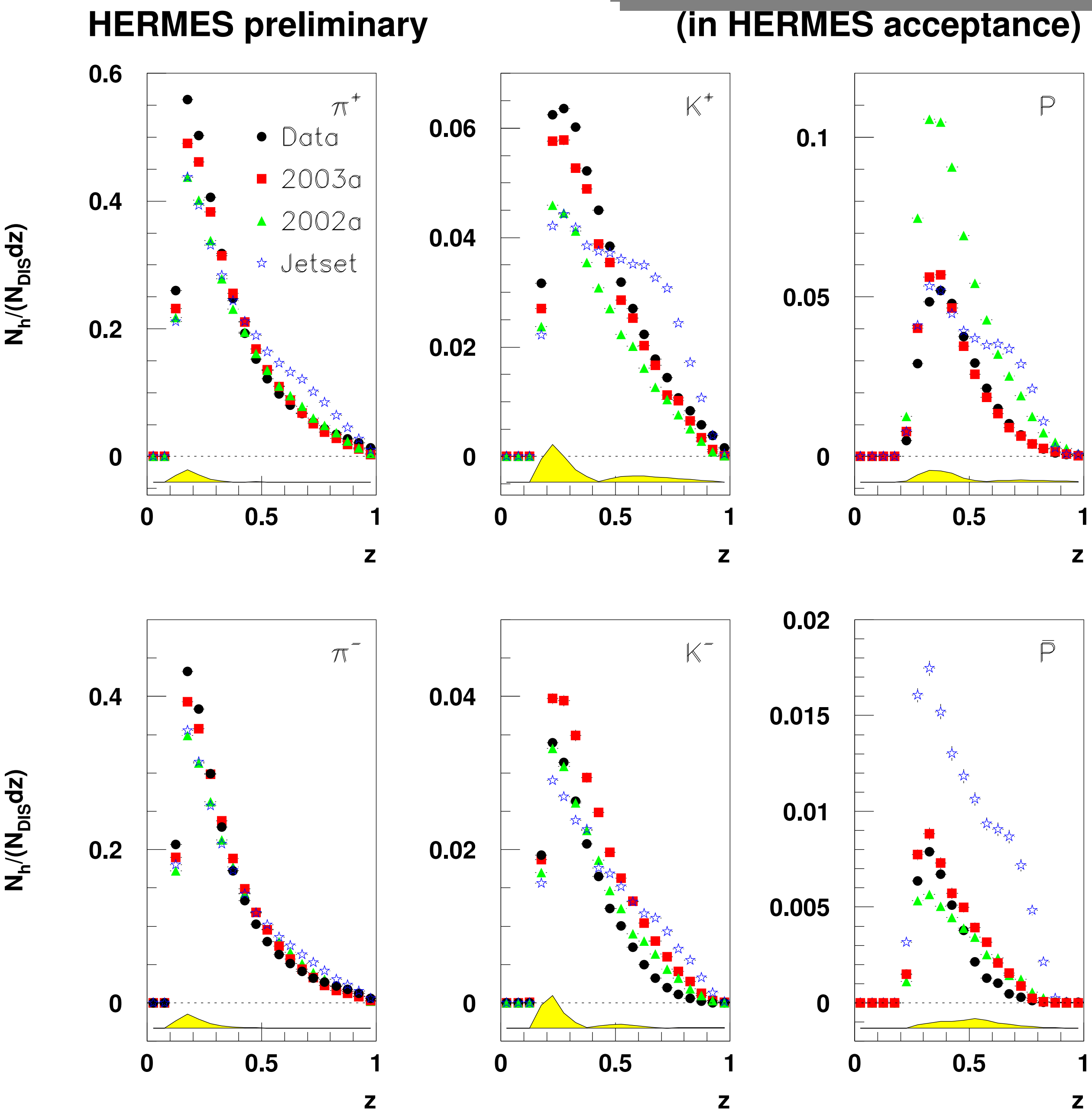
Smeared vs. tracked MC data (I)



Smeared vs. tracked MC data (II)



Tune comparison (I)



- $z = \frac{E_h}{E - E'}$
- Pions

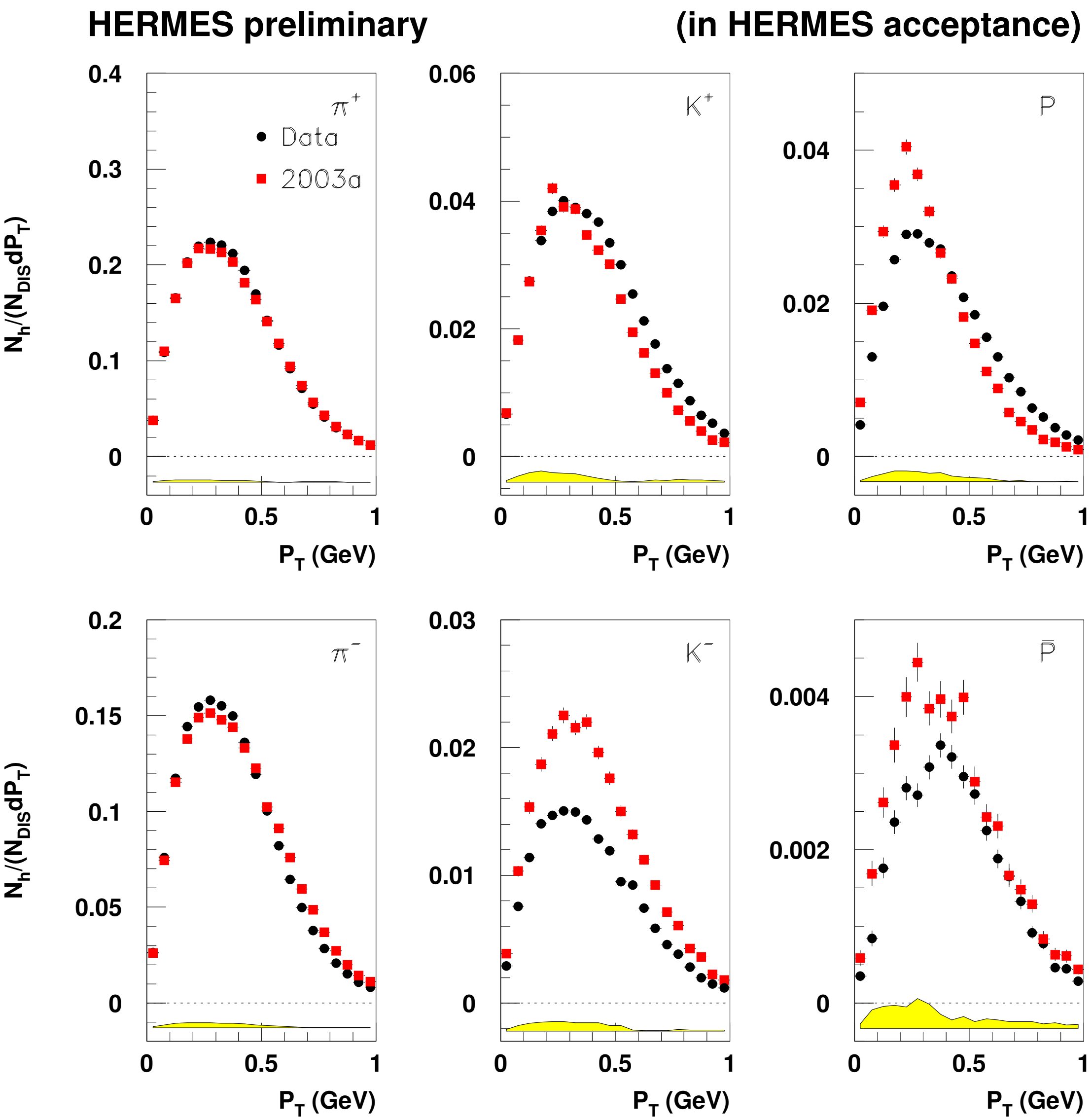
  good agreement
- (A-)Protons

  Latest parameter set is the first to reproduce both P- and $\bar{\text{P}}$- multiplicities reasonably well
- Kaons

  $\rightarrow$ contribution from excl. $e^+p \rightarrow e^+\Lambda K^+$?

  $\rightarrow$ is $s(x) \neq \bar{s}(x)$?

Tune comparison (II)



Tune comparison (III)

Parameter	Jetset	2003a	Jetset	2002a
		Set	Default	Set
qq_{supp}	PARJ(1)	0.03	0.10	0.02
$q^s q^s_{supp}$	PARJ(3)	0.25	0.40	0.40
q^s_{supp}	PARJ(2)	0.21	0.30	0.20
VM_{supp}	PARJ(11)	0.25	0.50	0.20
VM^s_{supp}	PARJ(12)	0.30	0.60	0.60
σ	PARJ(21)	0.38	0.36	0.37
f	PARJ(23)	0.03	0.01	0.03
p_T^f	PARJ(24)	2.5	2.00	2.50
a	PARJ(41)	1.13	0.30	1.74
b	PARJ(42)	0.37	0.58	0.23
a_{qq}	PARJ(45)	0.80	0.50	0.50
E_0	PARJ(33)	0.20	0.80	0.80
χ^2 (excl. P)		16.7	179.3	130.9
χ^2 (incl. P)		28.9	200.4	196.1

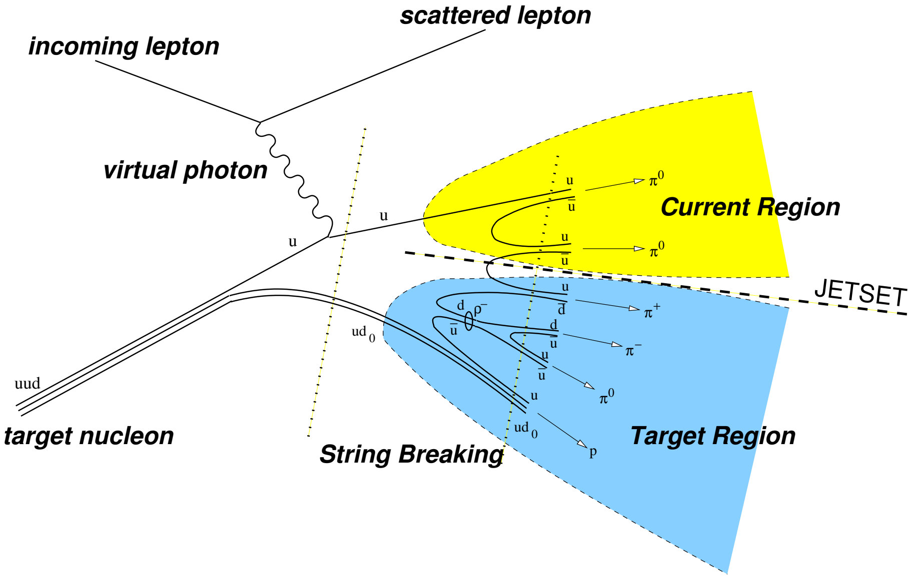
- ▷ 2002a: Set used for purities
- ▷ 2003a: Current best set
- ▷ Higher suppression of di-quarks and s-quarks:

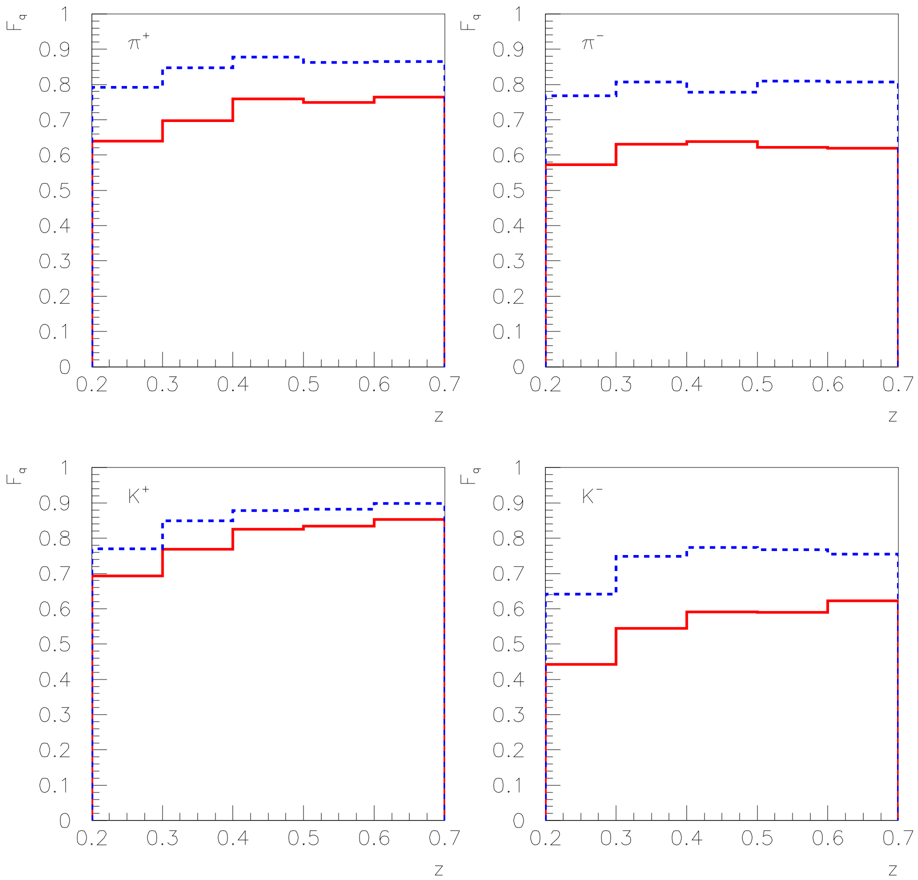
$$\frac{(\bar{P}/\pi)_{\mathrm{H1}}}{(\bar{P}/\pi)_{\mathrm{LEP}}} = 0.5$$

$$\frac{(K/\pi)_{\mathrm{H1}}}{(K/\pi)_{\mathrm{LEP}}} = 0.7$$

($\Rightarrow$ not a $\sqrt{s}$ problem)

Target vs. Current Fragmentation (I)





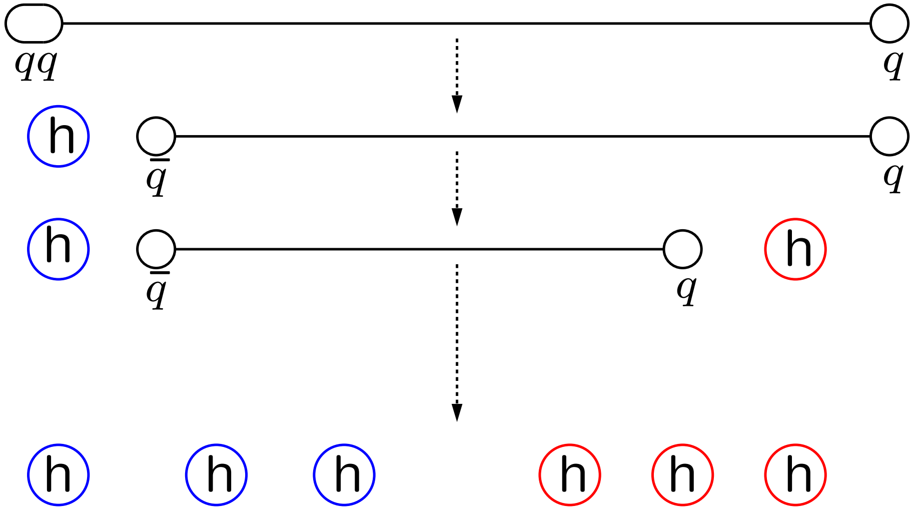
How to distinguish between TFR and CFR?

Suggestion: Use pointer in JETSET which designates the endpoints of the string the particle was produced from. (→ MSTU(16))

⇒ Observation: significant contribution of TFR

(→ A. Kotzinian, hep-ph/0211162)

Target vs. Current Fragmentation (II)



String break is governed by the *symmetric* fragmentation function $f(z)$

$\Downarrow$

Iterating left $\rightarrow$ right and right $\rightarrow$ left should give the same result on averrage.

$\Downarrow$

Especially for quarks produced in the 'center' of the string, the choice TFR or CFR is arbitrary.

Random choice at each iteration from which side the next step should be taken.

$$\Rightarrow \quad TFR \sim CFR$$

Conclusion & Outlook

- Considerable improvement has been achieved to describe HERMES multiplicities by the LUND model
- Classifying the produced hadrons into target fragments and current fragments according to the 'mother pointers' provided by the LUND model is not reasonable
- Fragmentation functions coming soon