P. Schüler
DIS 97

Semi-inclusive

- 95 Running
- 96 Running
- Semi-incl. formalism
- d_v/u_v, sea flavor asymmetry (unpol.)
- semi-incl. asymmetries
- Λ, ρ, φ, ...
- Upgrade Plans

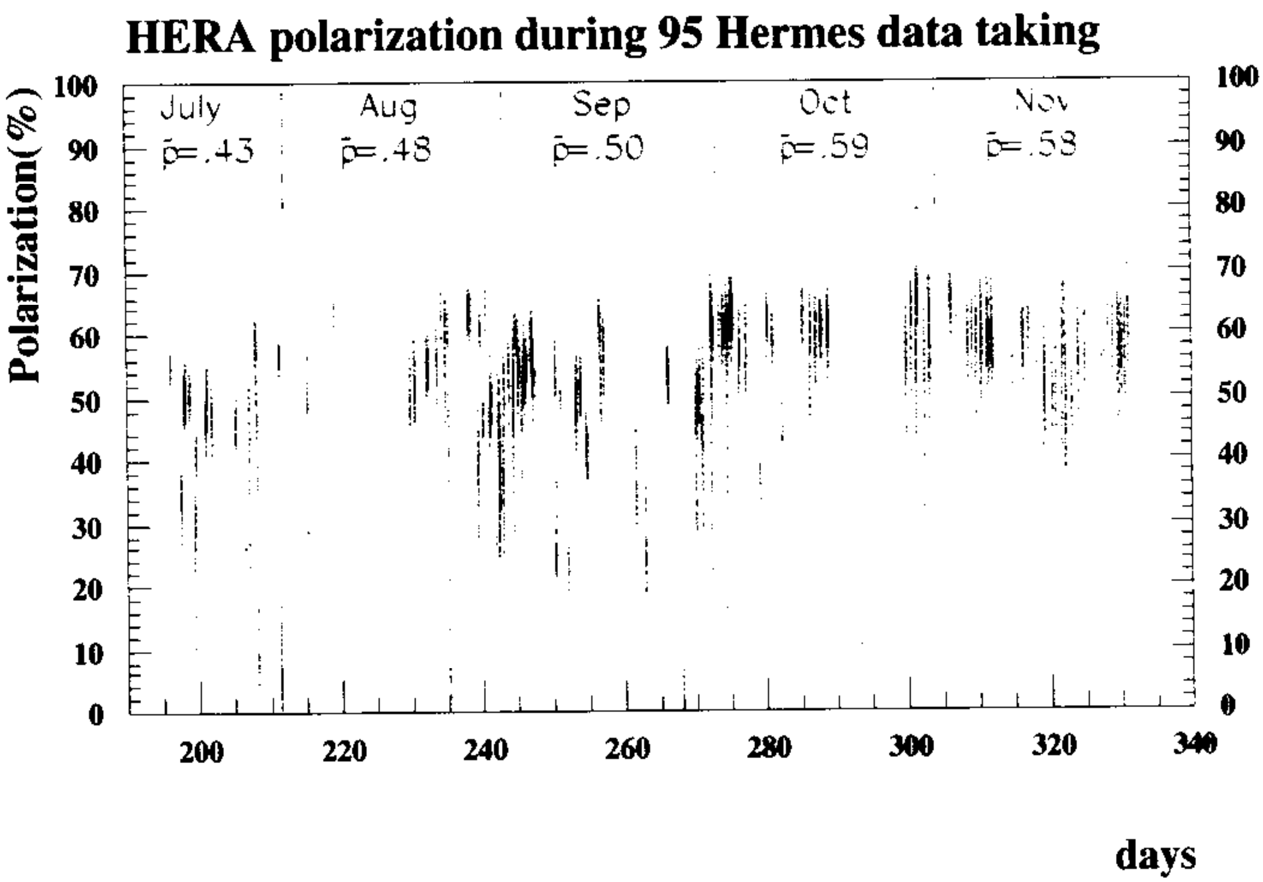
1995 Running

- commissioning of experiment
- pol. ^3He - target : $\sim 10^{14}$ atoms/cm^2
  $\langle P(^3He) \rangle \sim 47\%$
  $\Delta P/P \sim 5\%$
- pol. e^+ beam : $\langle P_e \rangle \sim 52\%$ [ ]
  $\Delta P/P \sim 5.5\%$
- 5×10^6 raw DIS events on $^3\vec{He}$
  $\longrightarrow 2.7 \times 10^6$ after data quality cuts

<u>Yields from $^3\vec{He}$</u>

h^+	$\sim$	450 K	K_s^0	$\sim$	2 K
h^-	$\sim$	300 K	η	$\sim$	2 K
π^+	$\sim$	53 K	ρ^0	$\sim$	10 K
π^-	$\sim$	38 K	ϕ	$\sim$	2 K
π^0	$\sim$	100 K	$\Lambda^0, \bar{\Lambda}^0$	$\sim$	2 K
			J/ψ	$\sim$	50

- additional $\sim 1 \times 10^6$ DIS events on unpol. H_2, D_2



HERA polarization during 95 Hermes data taking
Polarization(%)
July
p̄=.43
Aug
p̄=.48
Sep
p̄=.50
Oct
p̄=.59
Nov
p̄=.58
0
10
20
30
40
50
60
70
80
90
100
200
220
240
260
280
300
320
340
days

1996 Running

- polarized atomic hydrogen gas target [] []
  $\sim 7 \times 10^{13}$ atoms/cm^2
  $\langle P_p \rangle \sim 92\% \pm ?$
  complication due to formation of H_2 molecules
  → dilution: still under study
  → polarized Bhabba []

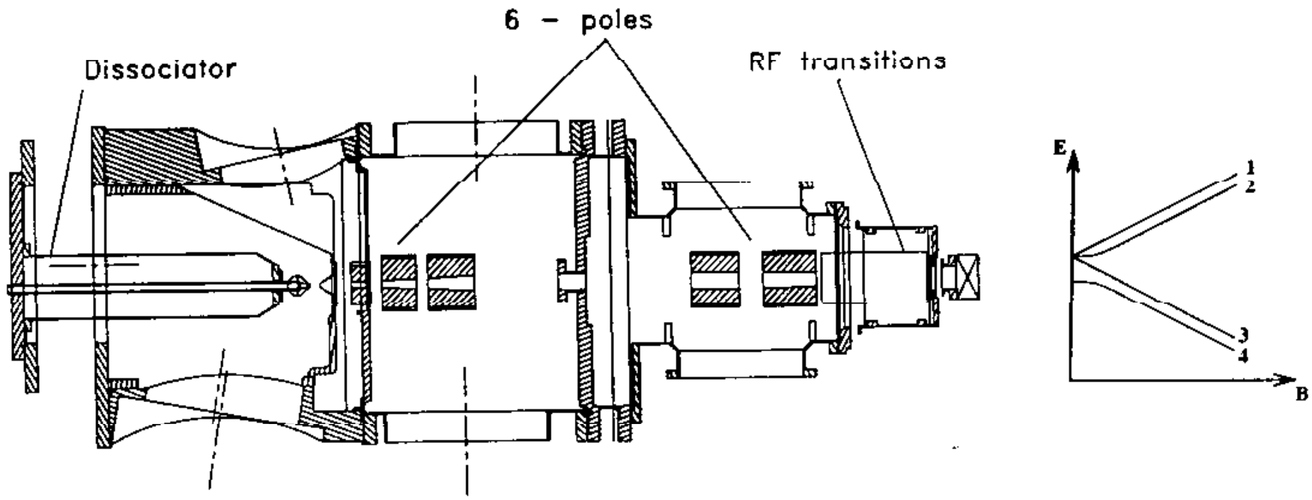
- HERA beam delivery increased
  HERMES efficiency " []
  data quality "
  trigger less sensitive to proton backgr.
  improved reliability of trans. beam polarimeter:
  $\Delta P_e / P_e$: 5.5% → 3.5%
  new additional long. beam polarimeter
  (still being commissioned)

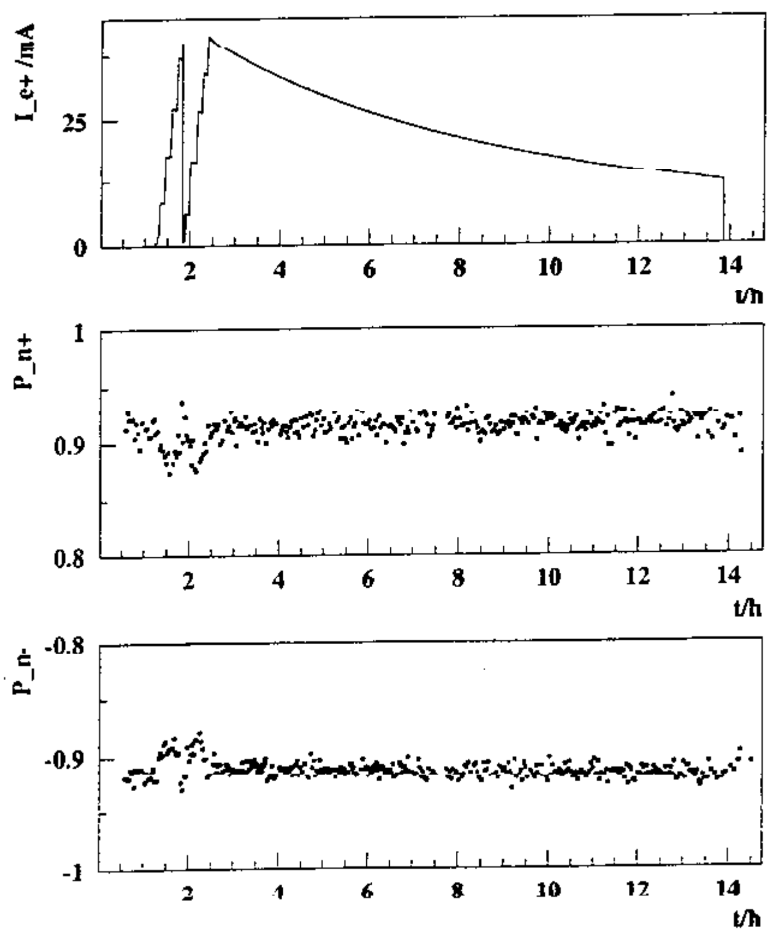
- $\sim 1.4 \times 10^6$ DIS events on pol. $\vec{H}$

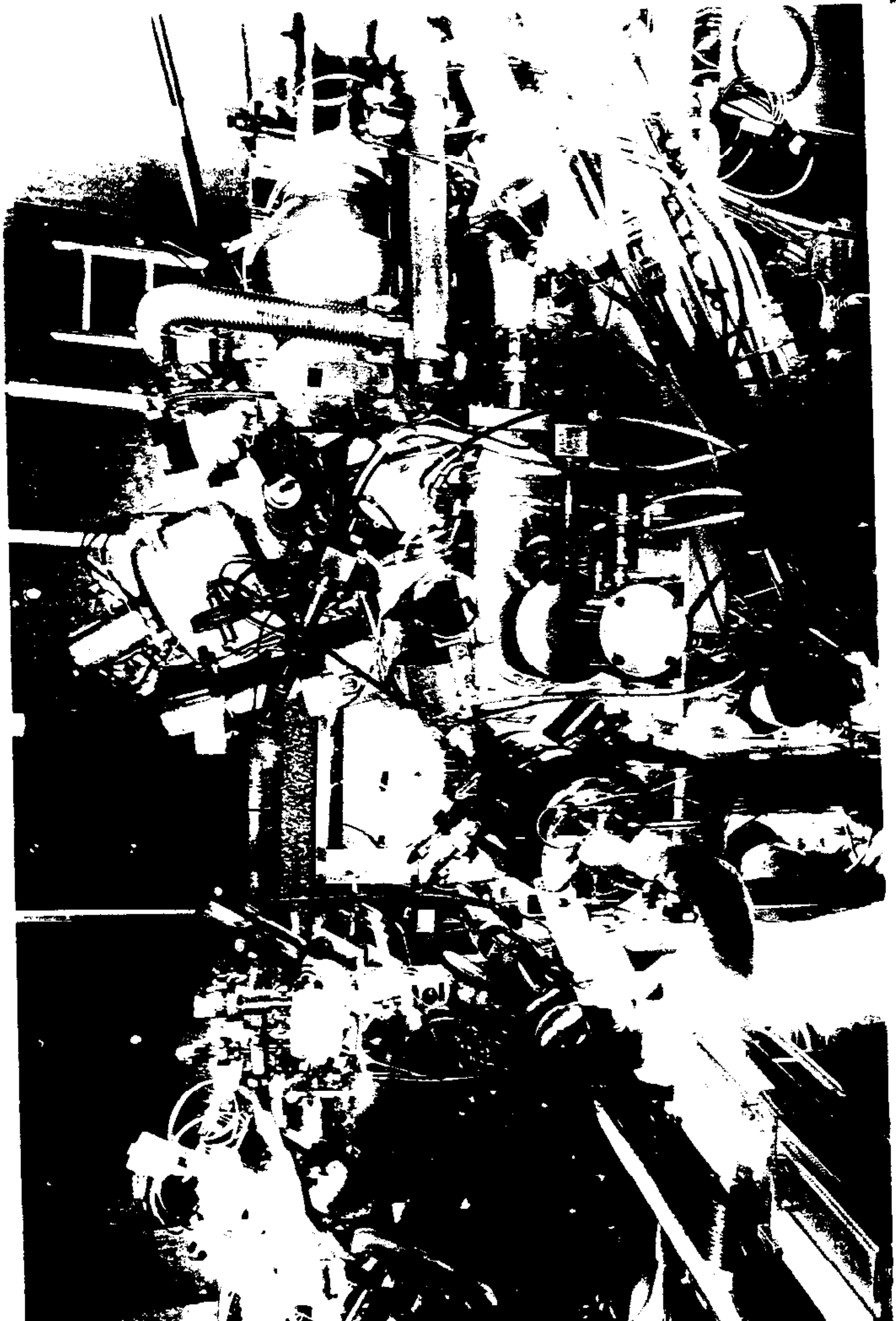
- $\sim 4 \times 10^6$ DIS events on unpol. $H_2, D_2, {}^3He$

- Lower Cerenkov threshold: 5.5 → 4 GeV/c
  increased identified pion yields (30% C_4F_{10})

Atomic Beam Source (ABS)

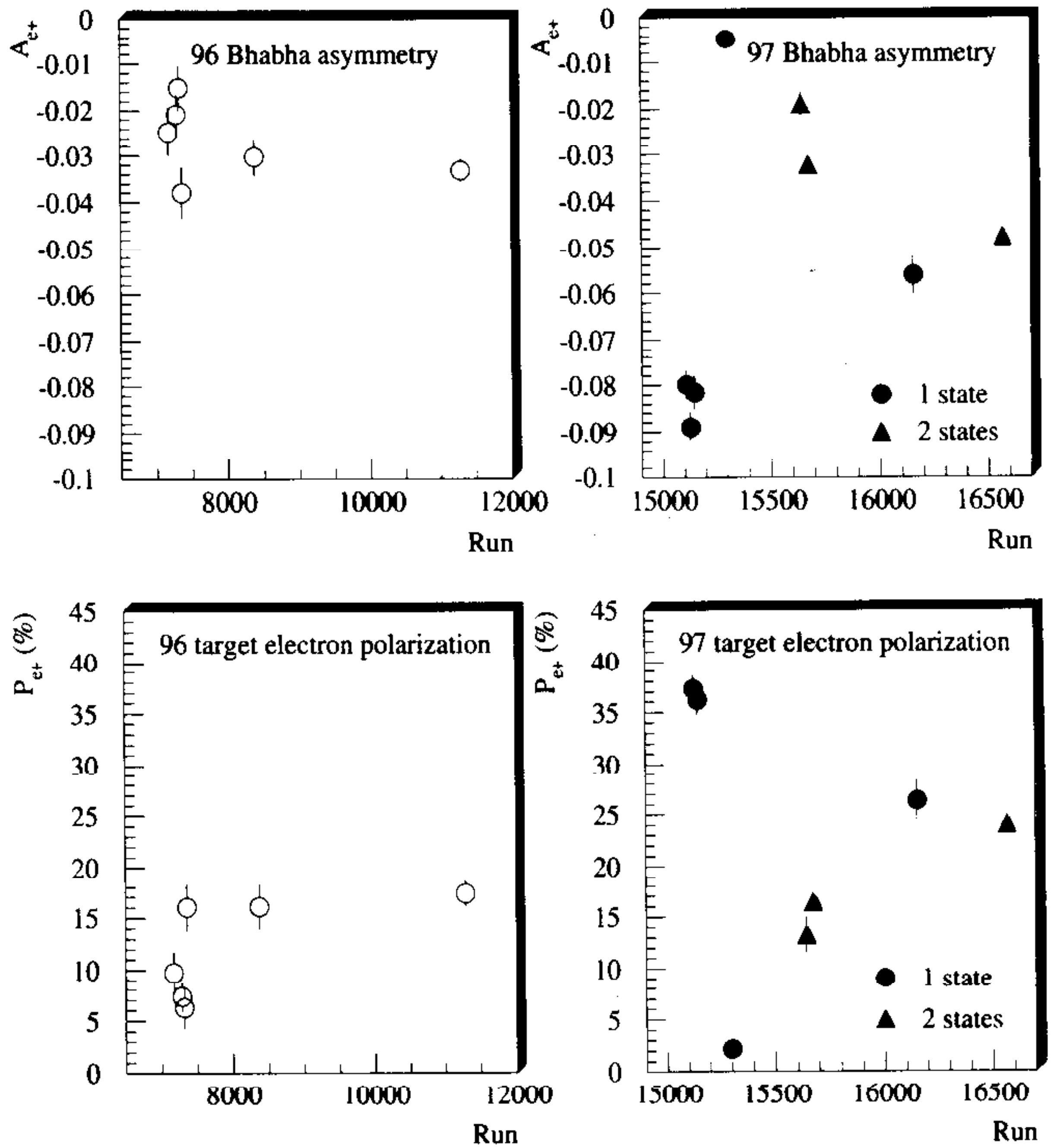






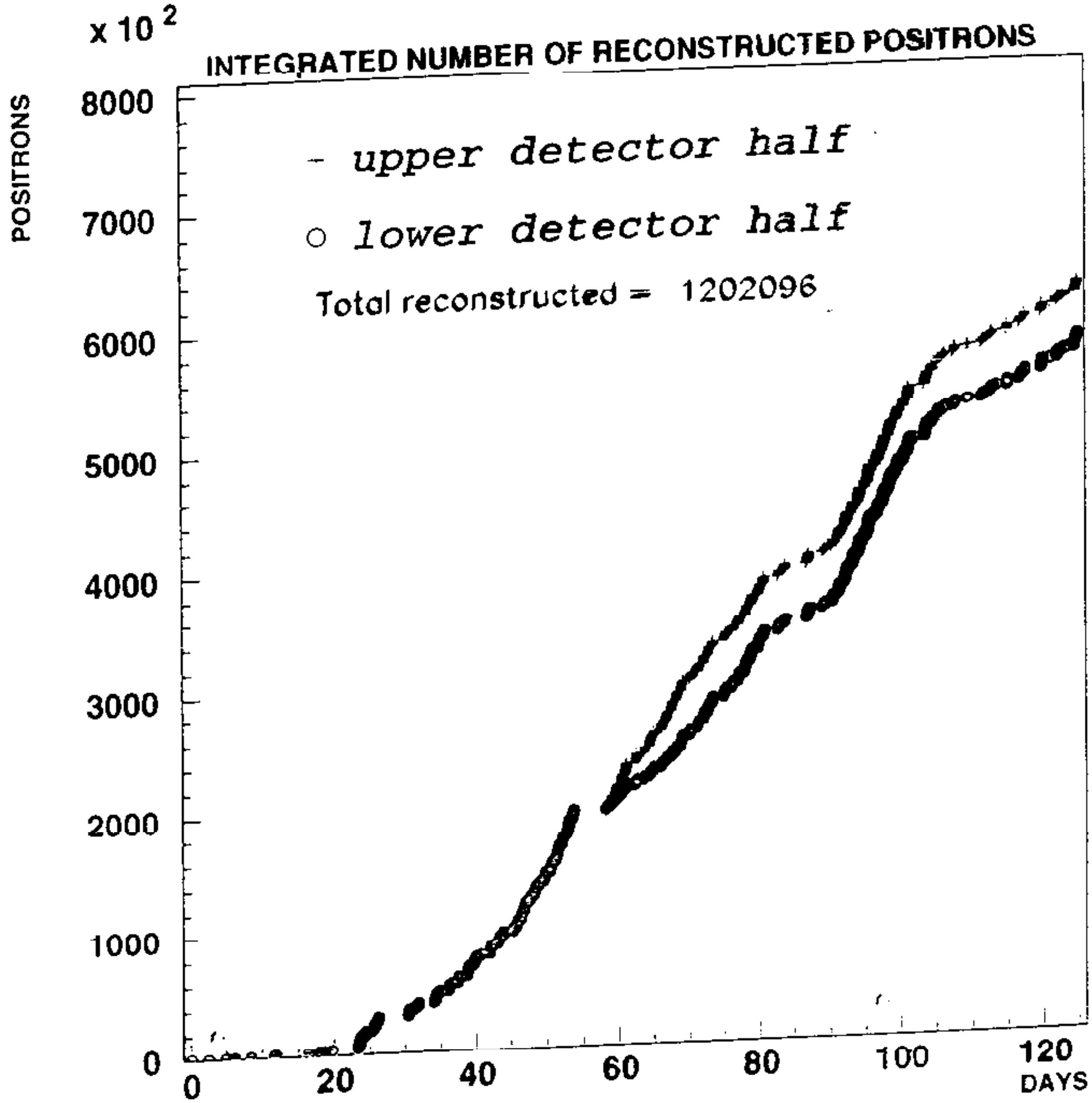
Summary of the 96 and 97 Data

PRELIMINARY!



Th. Benisch hermes April 1997

96 pol. Hydrogen data



DIS Structure Functions in the QCD Parton Model:

$$F_1(x,Q^2) = \sum_f e_f^2 \frac{q_f^+(x,Q^2) + q_f^-(x,Q^2)}{2}$$

$$g_1(x,Q^2) = \sum_f e_f^2 \frac{q_f^+(x,Q^2) - q_f^-(x,Q^2)}{2}$$

Asymmetry:

$$A_1(x,Q^2) = \frac{\sum_f e_f^2 \left[q_f^+(x,Q^2) - q_f^-(x,Q^2)\right]}{\sum_f e_f^2 \left[q_f^+(x,Q^2) + q_f^-(x,Q^2)\right]}$$

explicitely:

$$F_1^p(x,Q^2) = \frac{1}{2}\left(\frac{4}{9}u + \frac{1}{9}d + \frac{1}{9}s + \frac{4}{9}\bar{u} + \frac{1}{9}\bar{d} + \frac{1}{9}\bar{s}\right)$$

$$F_1^n(x,Q^2) = \frac{1}{2}\left(\frac{1}{9}u + \frac{4}{9}d + \frac{1}{9}s + \frac{1}{9}\bar{u} + \frac{4}{9}\bar{d} + \frac{1}{9}\bar{s}\right)$$

$$g_1^p(x,Q^2) = \frac{1}{2}\left(\frac{4}{9}\Delta u + \frac{1}{9}\Delta d + \frac{1}{9}\Delta s + \frac{4}{9}\Delta\bar{u} + \frac{1}{9}\Delta\bar{d} + \frac{1}{9}\Delta\bar{s}\right)$$

$$g_1^n(x,Q^2) = \frac{1}{2}\left(\frac{1}{9}\Delta u + \frac{4}{9}\Delta d + \frac{1}{9}\Delta s + \frac{1}{9}\Delta\bar{u} + \frac{4}{9}\Delta\bar{d} + \frac{1}{9}\Delta\bar{s}\right)$$

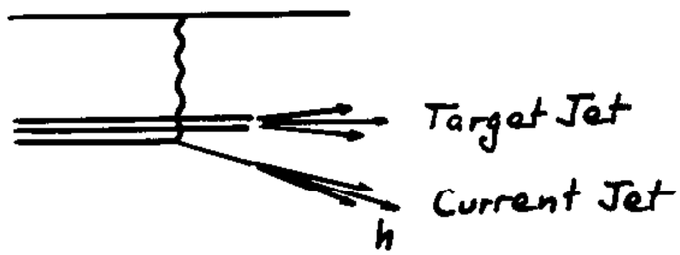
even more explicitely:

$$\begin{aligned} F_1^p(x,Q^2) = \frac{1}{2}\Big[& \frac{4}{9}\left(u_V + u_S + \bar{u}_S\right) \\ & + \frac{1}{9}\left(d_V + d_S + \bar{d}_S\right) \\ & + \frac{1}{9}\left(s_S + \bar{s}_S\right)\Big] \end{aligned}$$

valence
sea
decompositi

etc. for F_1^n, g_1^p and g_1^n

Beyond Structure Functions:
semi-inclusive scattering



$$z = \frac{E_h}{\nu}$$

$$\frac{1}{\sigma_{tot}} \cdot \frac{d\sigma}{dz} = \frac{\sum_f e_f^2 \, q_f(x, Q^2) \, D_f^h(z)}{\sum_f e_f^2 \, q_f(x, Q^2)}$$ Factorization Ansatz

$$\sum_f \int_0^1 D_f^h(z)\, dz = n_h$$ (multiplicity)

$$\sum_h \int_0^1 z D_f^h(z)\, dz = 1$$ (momentum conservation)

favored $D^+(z) = D_u^{\pi^+} = D_d^{\pi^-} = D_{\bar{d}}^{\pi^+} = D_{\bar{u}}^{\pi^-}$

isospin & charge symmetry

unfavored $D^-(z) = D_d^{\pi^+} = D_u^{\pi^-} = D_{\bar{u}}^{\pi^+} = D_{\bar{d}}^{\pi^-}$

$$D^+(z) = 0.7\,(1-z)^{0.75}$$

$$D^-(z) = \frac{1-z}{1+z}\, D^+(z)$$

EMC parametrization

Ratio of Valence Quark Distributions

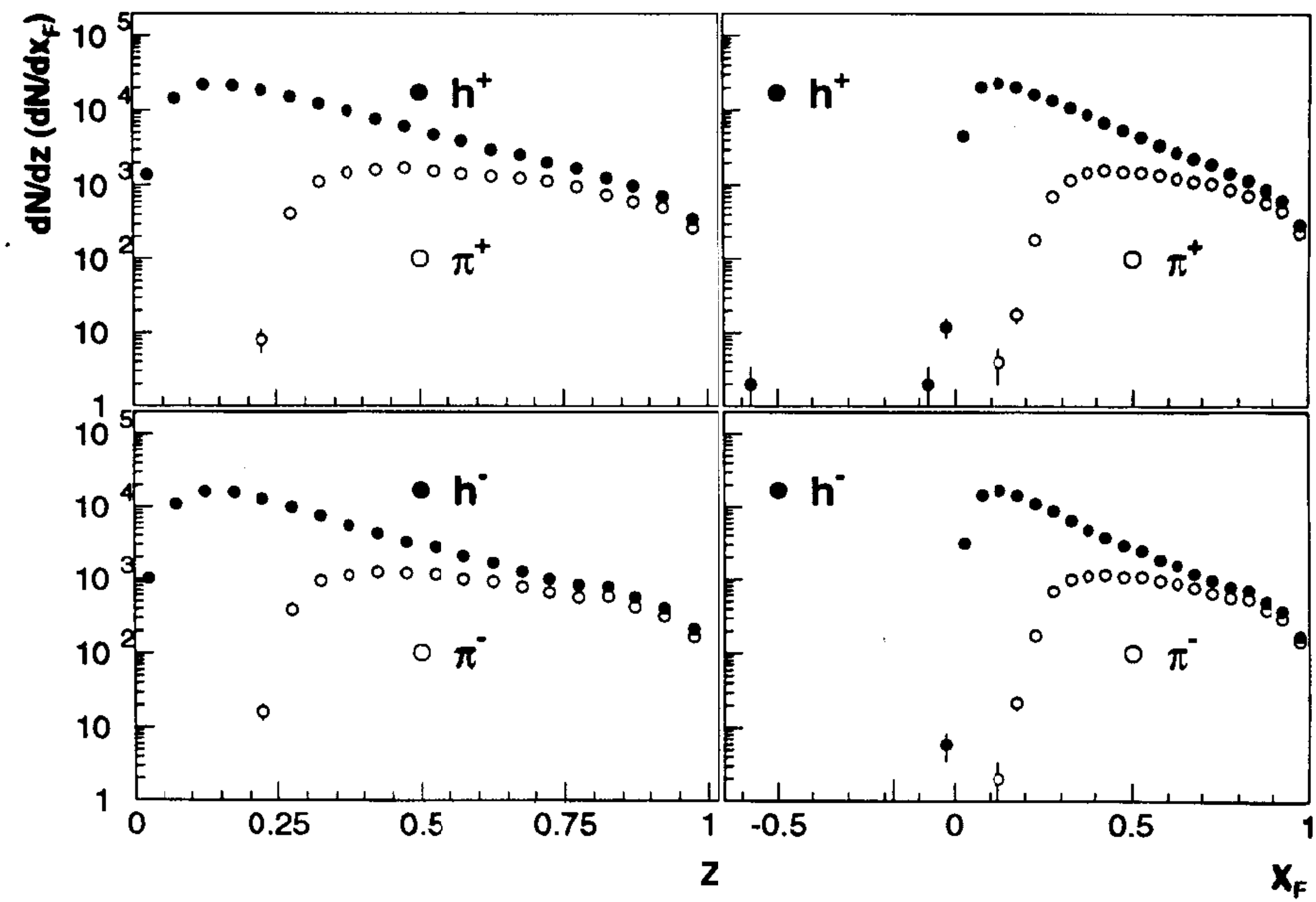
$$\underbrace{\frac{1}{\sigma_{tot}}}_{\propto N^{e^+}}\frac{d\sigma_{\mathrm{N}}^{h}(x,z)}{dz} = e\frac{\sum_i e_i^2 f_{i/\mathrm{N}}(x)\cdot D_i^h(z)}{\underbrace{\sum_i e_i^2 f_{i/\mathrm{N}}(x)}_{F_2^{\mathrm{N}}}}$$

⟹Comparing Proton and Neutron:

$$\begin{aligned}
\frac{1}{N_{e^+}^{\mathrm{p}}}\left(\frac{dN_{\mathrm{p}}^{\pi^+}}{dz}-\frac{dN_{\mathrm{p}}^{\pi^-}}{dz}\right) &= \frac{x}{F_2^{\mathrm{p}}}\left(\frac{4}{9}u_v-\frac{1}{9}d_v\right)\left(D^+-D^-\right)\,,\\
\frac{1}{N_{e^+}^{\mathrm{n}}}\left(\frac{dN_{\mathrm{n}}^{\pi^+}}{dz}-\frac{dN_{\mathrm{n}}^{\pi^-}}{dz}\right) &= \frac{x}{F_2^{\mathrm{n}}}\left(\frac{4}{9}d_v-\frac{1}{9}u_v\right)\left(D^+-D^-\right)
\end{aligned}$$

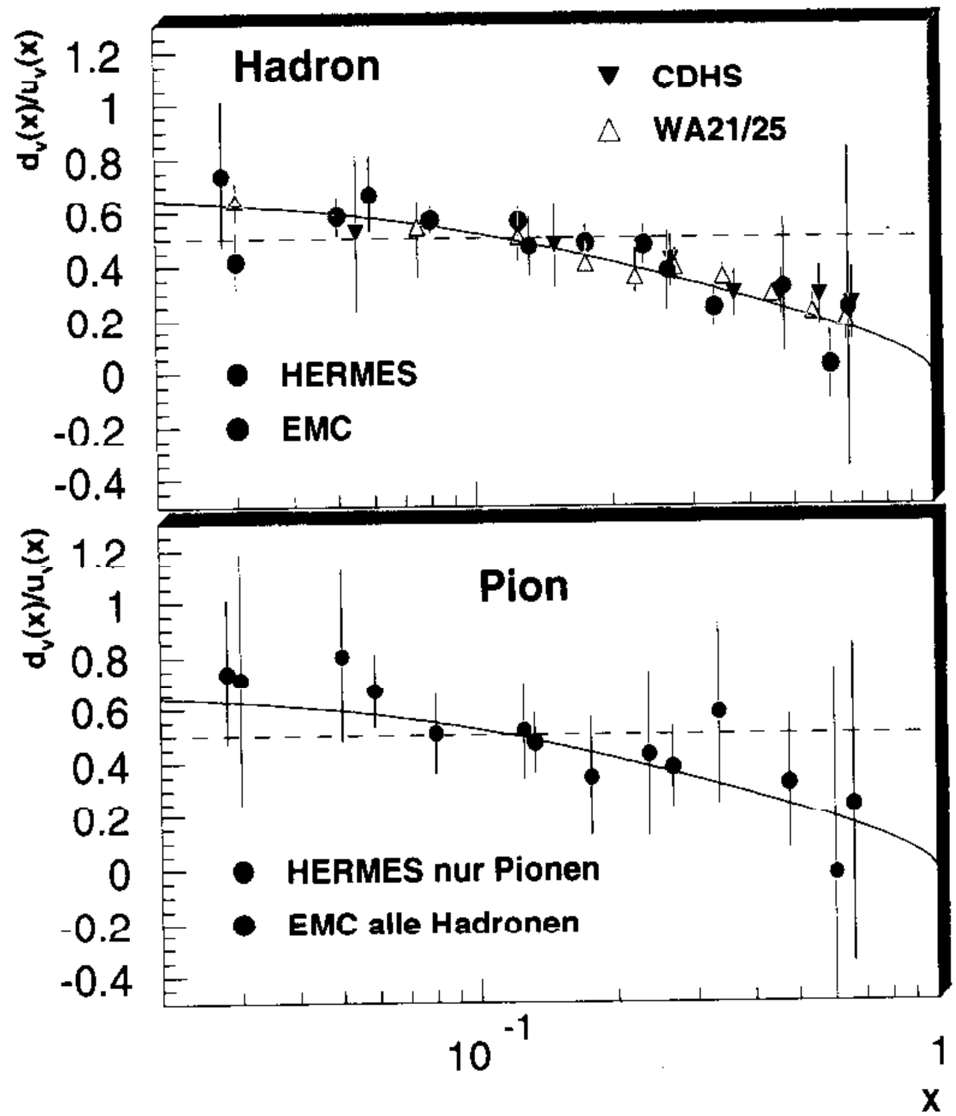
- Sea contributions cancel
- Ratio (p/n) independent of Fragmentation functions

⟹Gives measure of $\frac{d_v(x)}{u_v(x)}$


dN/dz (dN/dx_F)
h+
π+
h-
π-
z
x_F

$$\frac{d_v(x)}{u_v(x)}$$

K. Ackerstaff



K. Ackerstaff Thesis

detected hadrons and the number N_{e^+} of detected positrons like

$$\frac{1}{\sigma_N(x)}\frac{d\sigma_N^h(x,z)}{dz} = \frac{\sum_i e_i^2 f_{iN}(x) D_i^h(z)}{\sum_i e_i^2 f_{iN}(x)} \sim \frac{N_h(x,z)}{N_{e^+}(x)} . \tag{6.13}$$

Using the fragmentation functions $D_i^{\pm}$ for a quark of flavor i fragmenting into positive/negative pion (or hadron) and the quark charges and distribution functions for only the light quarks including the strange quarks these numbers for the proton are:

$$\begin{aligned} N^{p\pi\pm} =& \\ &\frac{4}{9}uD_u^{\pm}(z) + \frac{4}{9}\bar{u}D_{\bar{u}}^{\pm}(z) + \frac{1}{9}dD_d^{\pm}(z) + \\ &\frac{1}{9}\bar{d}D_{\bar{d}}^{\pm}(z) + \frac{1}{9}sD_s^{\pm}(z) + \frac{1}{9}\bar{s}D_{\bar{s}}^{\pm}(z) \end{aligned} \tag{6.14}$$

and for the neutron assuming isospin invariance:

$$\begin{aligned} N^{n\pi\pm} =& \\ &\frac{4}{9}dD_u^{\pm}(z) + \frac{4}{9}\bar{d}D_{\bar{u}}^{\pm}(z) + \frac{1}{9}uD_d^{\pm}(z) + \\ &\frac{1}{9}\bar{u}D_{\bar{d}}^{\pm}(z) + \frac{1}{9}sD_s^{\pm}(z) + \frac{1}{9}\bar{s}D_{\bar{s}}^{\pm}(z) . \end{aligned}$$

Using the result from equation 2.45 one defines a ratio:

$$R(x,z) = \frac{\tau(x) - \bar{\tau}(x)}{\tau(x) + \bar{\tau}(x)} \left(\frac{3D^+(z) + 3D^-(z)}{5D^+(z) - 5D^-(z)}\right) \tag{6.15}$$

and uses the parameterization of the ratio of the fragmentation functions (Feynman & Field, EMC [Fie78][Arn89]):

$$D^+ = (1+z)/(1-z)D^- , \tag{6.16}$$

so that $R(x,z)$ becomes independent of the fragmentation functions:

$$R(x,z) = \frac{\tau(x) - \bar{\tau}(x)}{\tau(x) + \bar{\tau}(x)}\frac{3}{5}\frac{1}{z} . \tag{6.17}$$

The integral over this ratio is then directly proportional to the Gottfried sum:

$$\int_0^1 R(x,z)dx = 3S_G\frac{3}{5z} . \tag{6.18}$$

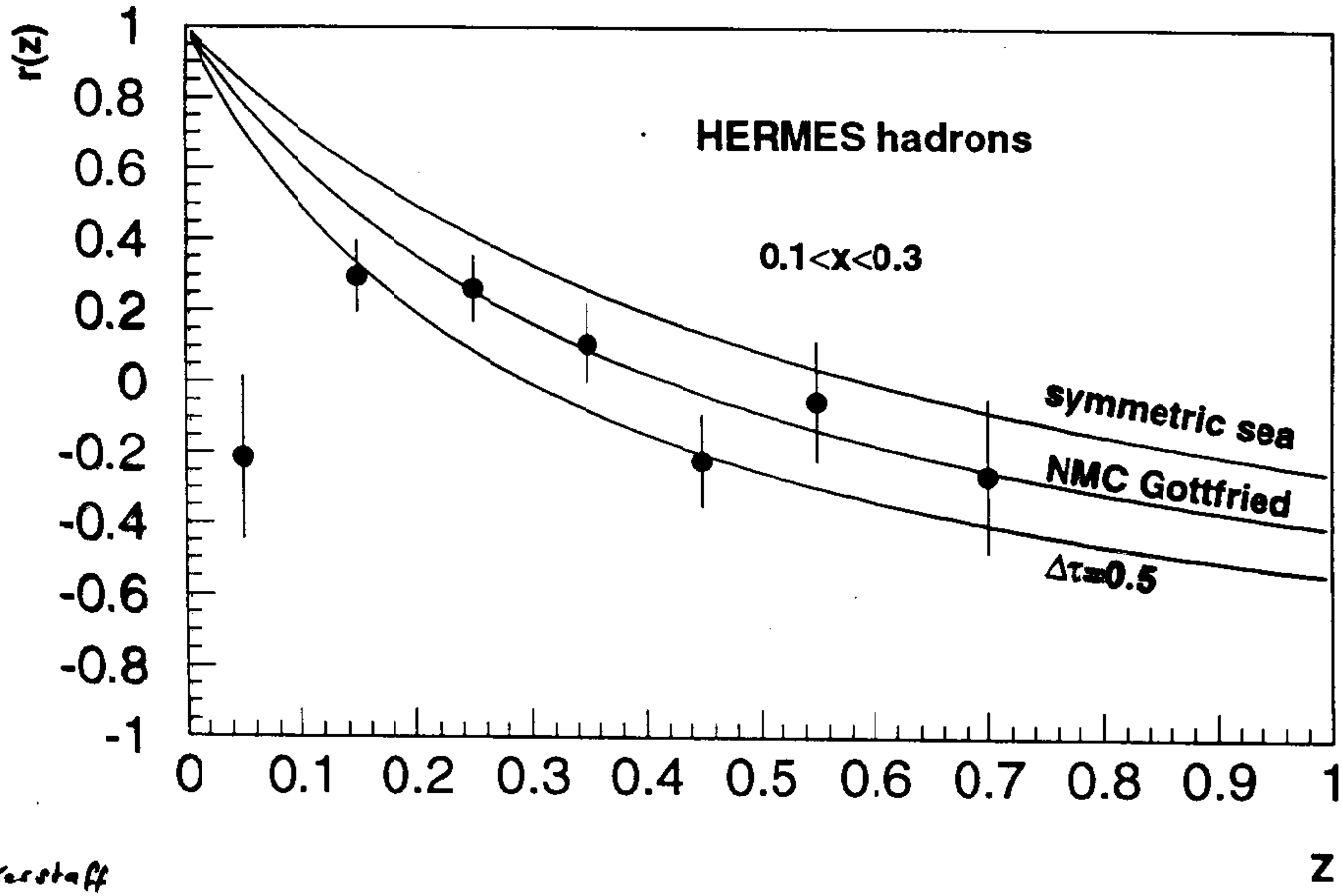
The ratio $R(x,z)$ in turn is proportional to the actually measured ratio $r(x,z)$:

$$\boxed{r(x,z) = \frac{N^{p\pi-} - N^{n\pi-}}{N^{p\pi+} - N^{n\pi+}}} \Rightarrow R(x,z) = \frac{1 + r(x,z)}{1 - r(x,z)} . \tag{6.19}$$

$$S_G = 2\int_0^1 dx\,\{F_1^p(x) - F_1^n(x)\} = \frac{1}{3}\int_0^1 dx\,\{u - d + \bar{u} - \bar{d}\}$$

$$S_G \neq \frac{1}{3} \longrightarrow \bar{u} \neq \bar{d} \qquad \text{NMC}$$

THE SEA QUARK FLAVOR ASYMMETRY



K. Ackerstaff

Semi-inclusive Spin Asymmetries

$$A_1^h(x, Q^2, z_{min}) = \frac{\sum_{f,h} e_f^2 \, \Delta q_f(x,Q^2) \int_{z_{min}}^1 dz \, D_f^h(z)}{\sum_{f,h} e_f^2 \, q_f(x,Q^2) \int_{z_{min}}^1 dz \, D_f^h(z)}$$

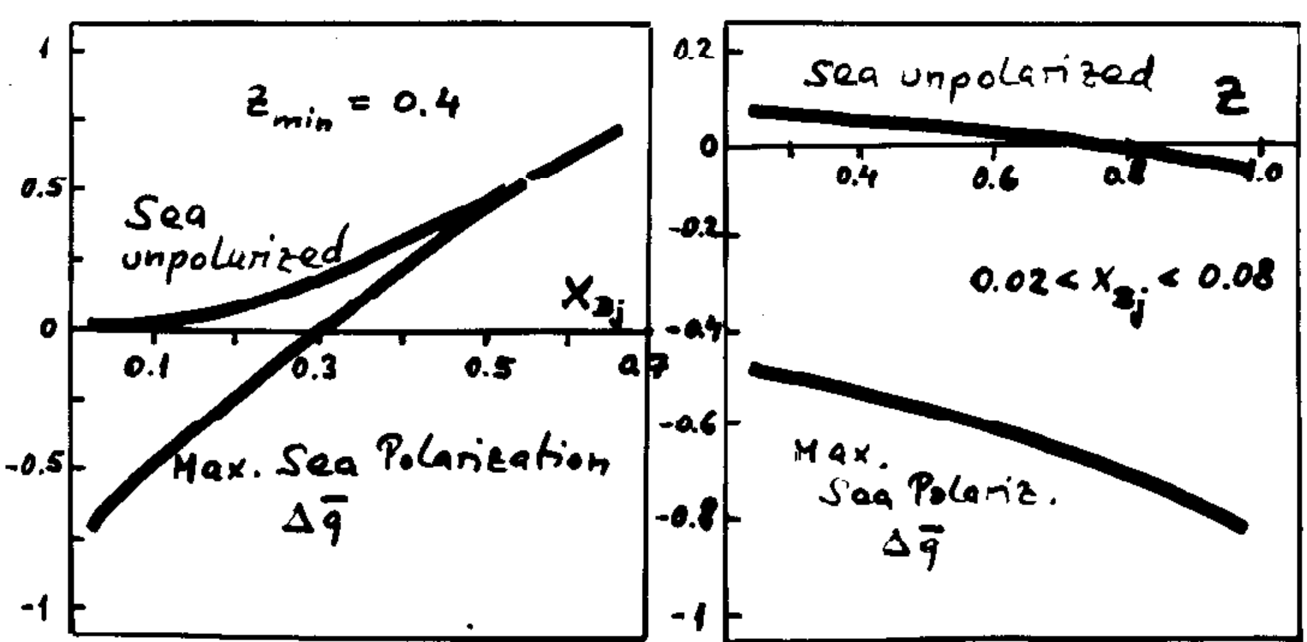
$D_f^h(z)$ = fragmentation function
assume: spin-independent

e.g. consider the special case:

$$\vec{e}\vec{p} \rightarrow e'\pi^- X$$

with $D^s \sim D^- \sim \frac{1-z}{1+z} D^+$; $\eta = \frac{1+z}{1-z}$

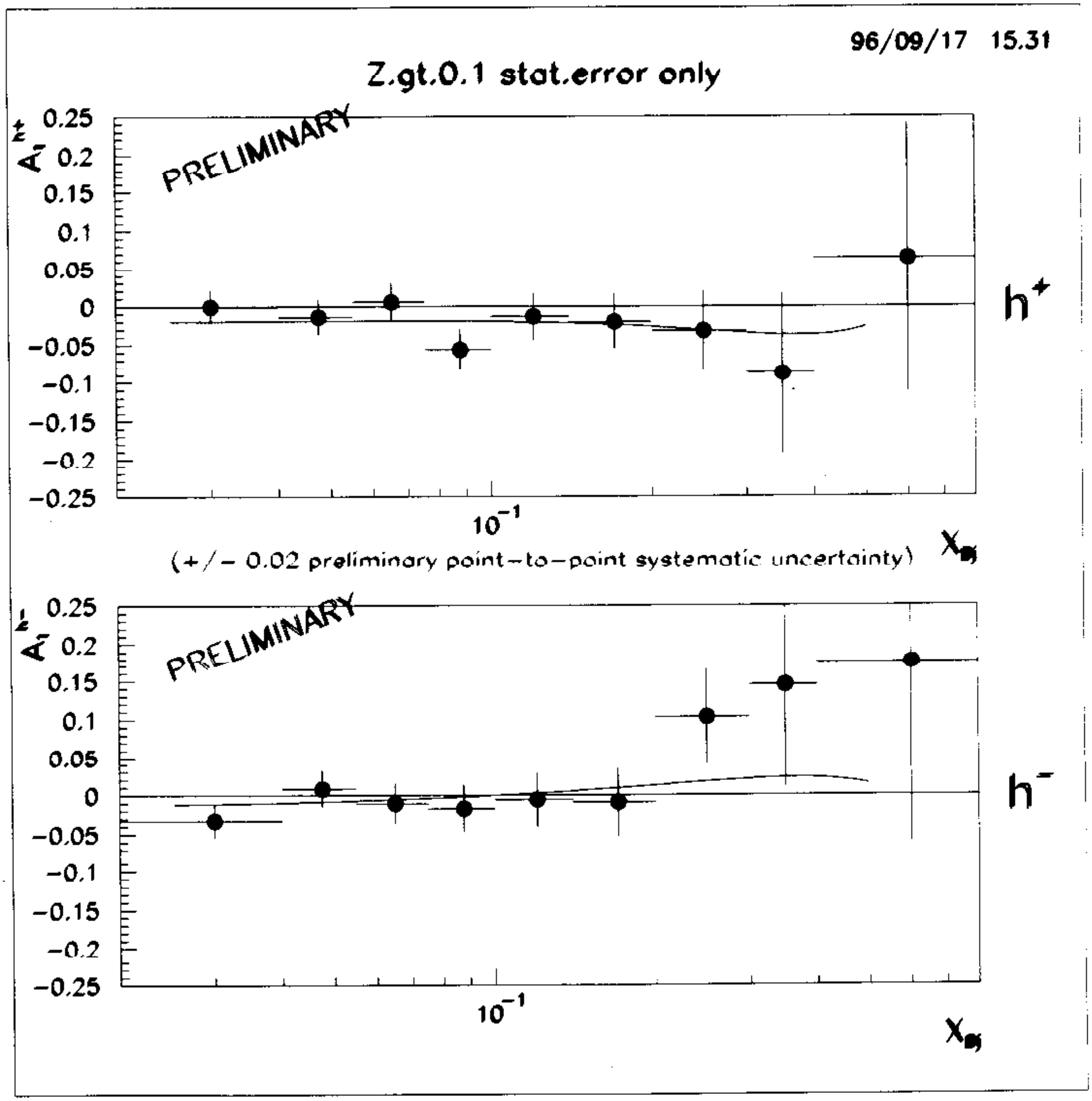
$$A_1^{\pi^-}(p) \sim \frac{4\Delta u_v + \eta \Delta d_v + 5(1+\eta)\Delta\bar{q} + 2\Delta s}{4u_v + \eta d_v + 5(1+\eta)\bar{q} + 2s}$$



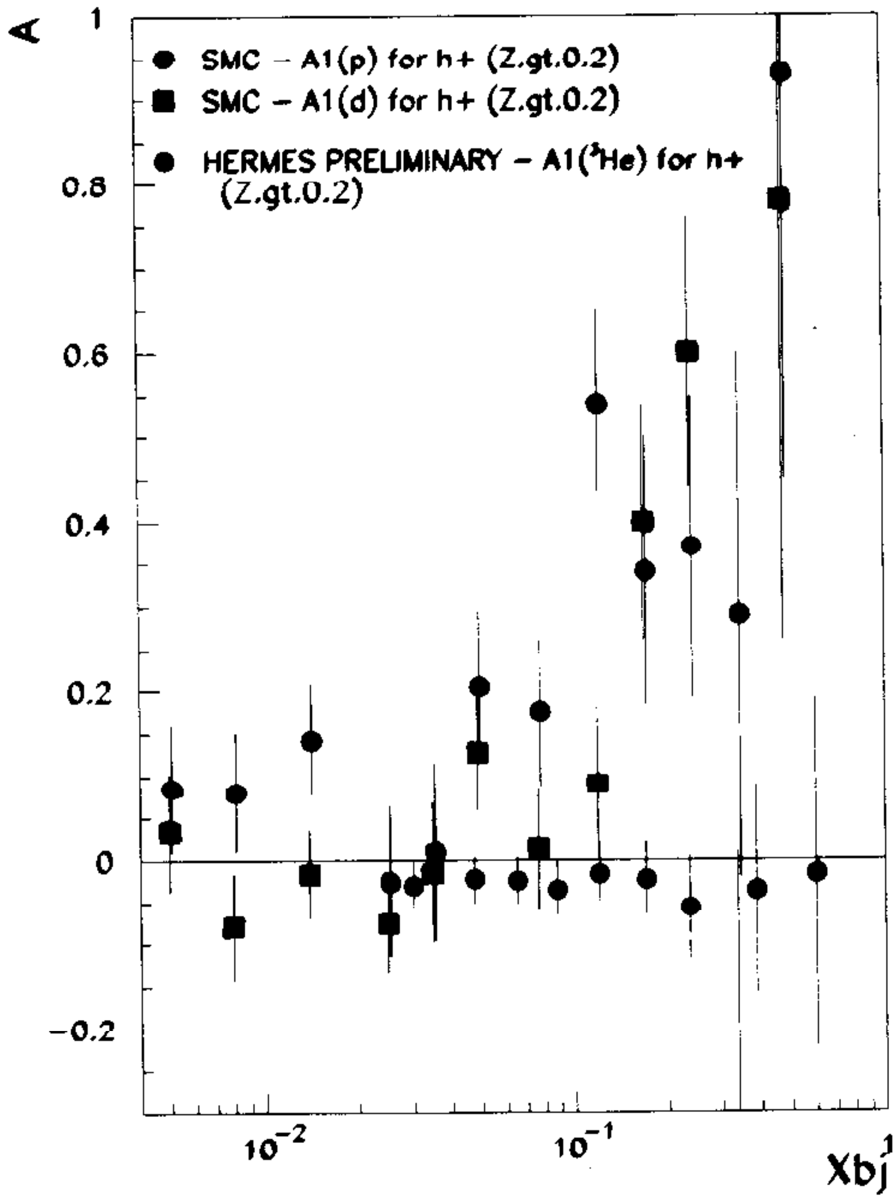
$\rightarrow$ good sensitivity to $\Delta\bar{q}$, but none to Δs

^3He

hermes
E. Bruins



semi-inclusive $h^{\pm}$
spin asymmetry

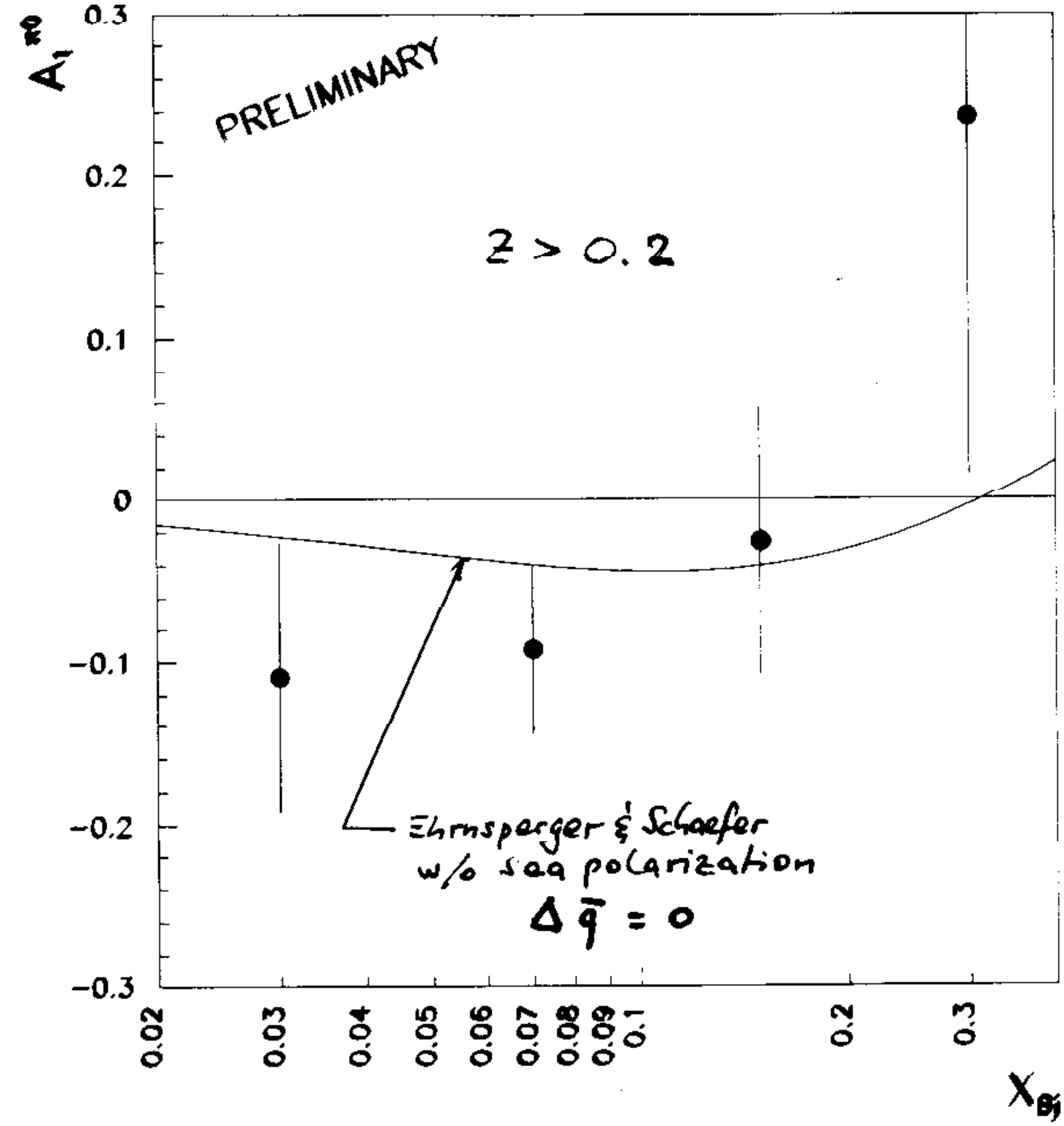

A
1
0.8
0.6
0.4
0.2
0
-0.2
SMC - A1(p) for h+ (Z.gt.0.2)
SMC - A1(d) for h+ (Z.gt.0.2)
HERMES PRELIMINARY - A1(³He) for h+ (Z.gt.0.2)
10^{-2}
10^{-1}
Xbj
1

^3He semi-inclusive π^0 Spin-asymmetry

hermes

P. Di Nezza

π^0 Asymmetry on ^3He



$$A_1^{\pi^0}(^3He) = \frac{4\Delta d_v + \Delta u_v + 10\Delta\bar{q}}{9u_v + 6d_v + 30\bar{q}}$$

Spin-dependent Λ electroproduction

Spin direction of Λ: self-analyzing from its parity-violating decay

Look for $u \to \Lambda$ spin transfer

$$\mathcal{P}_\Lambda = -\mathcal{P}_e \frac{y(2-y)}{1+(1-y)^2} \frac{\Delta u_\Lambda}{u_\Lambda} \sim 0.4\, \mathcal{P}_e \frac{\Delta u_\Lambda}{u_\Lambda}$$

- Long. pol. electron beam
- unpol. target (high density)
- reverse beam polarization

Polarization effects expected both in current & target fragmentation regime

Additional effects with pol. target

S. Tsolostokky - 1

Lamda's

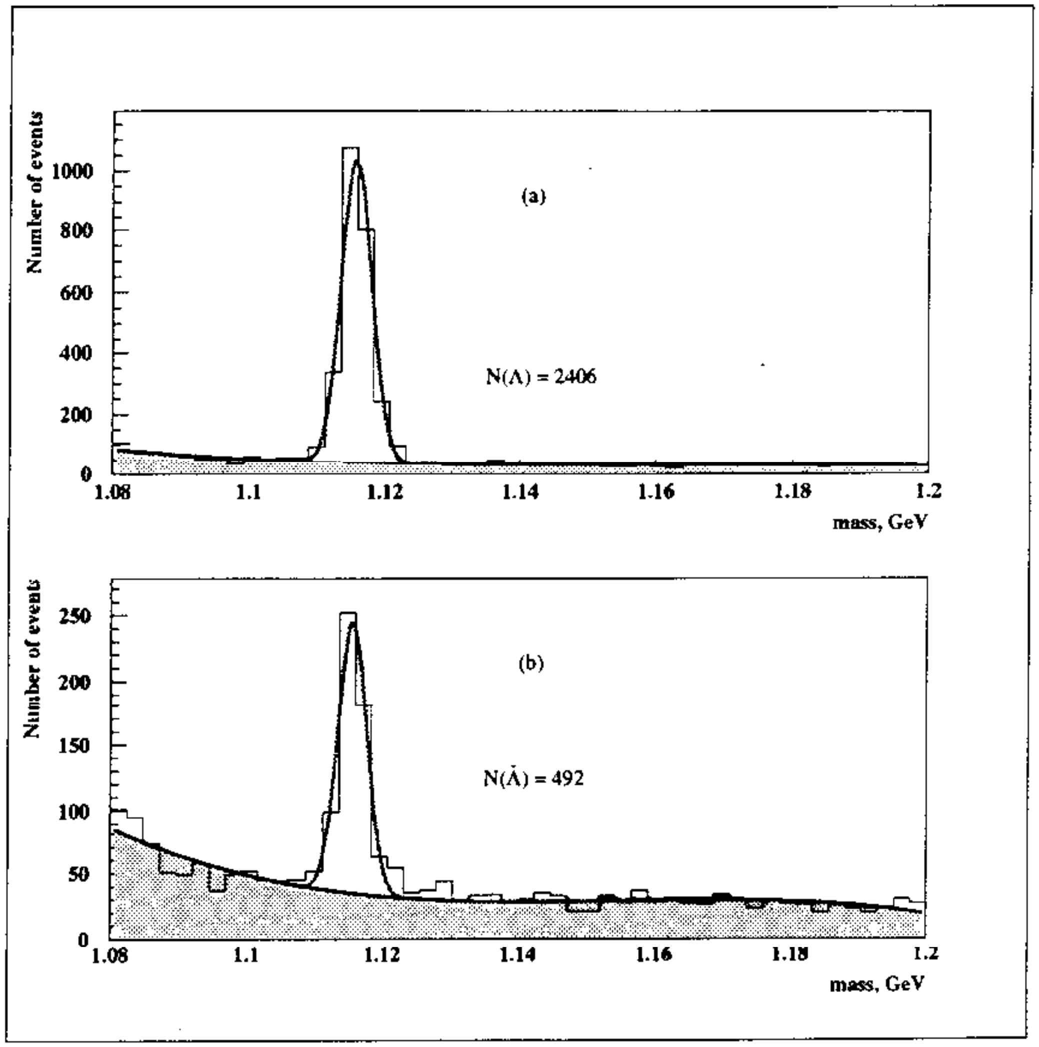


Figure 1: Invariant mass distributions for Λ (a) and $\bar{\Lambda}$(b) events with cuts.

Lamda's

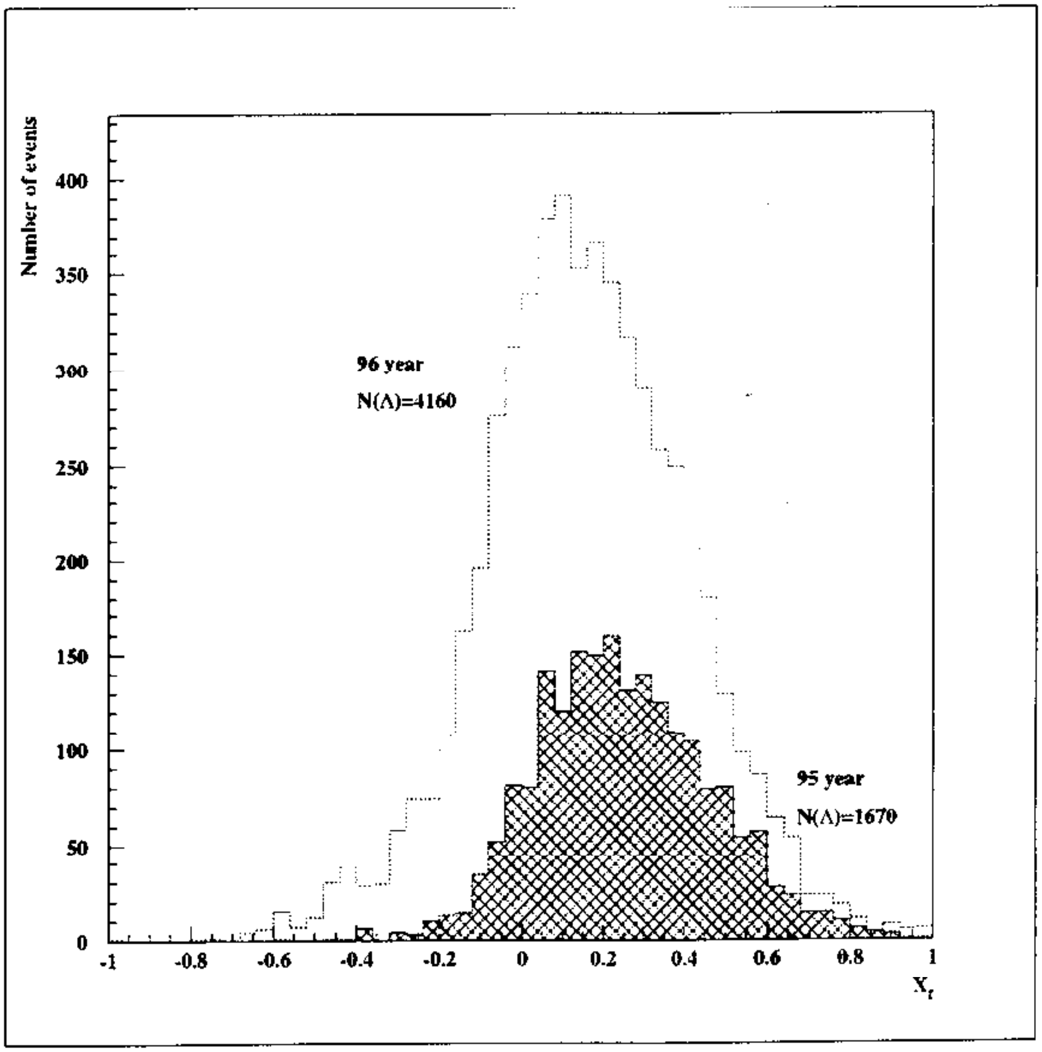


Figure 2: x_F-distributions for Λ-s obtained from 1995 and 1996 year data sets.

Lamda's

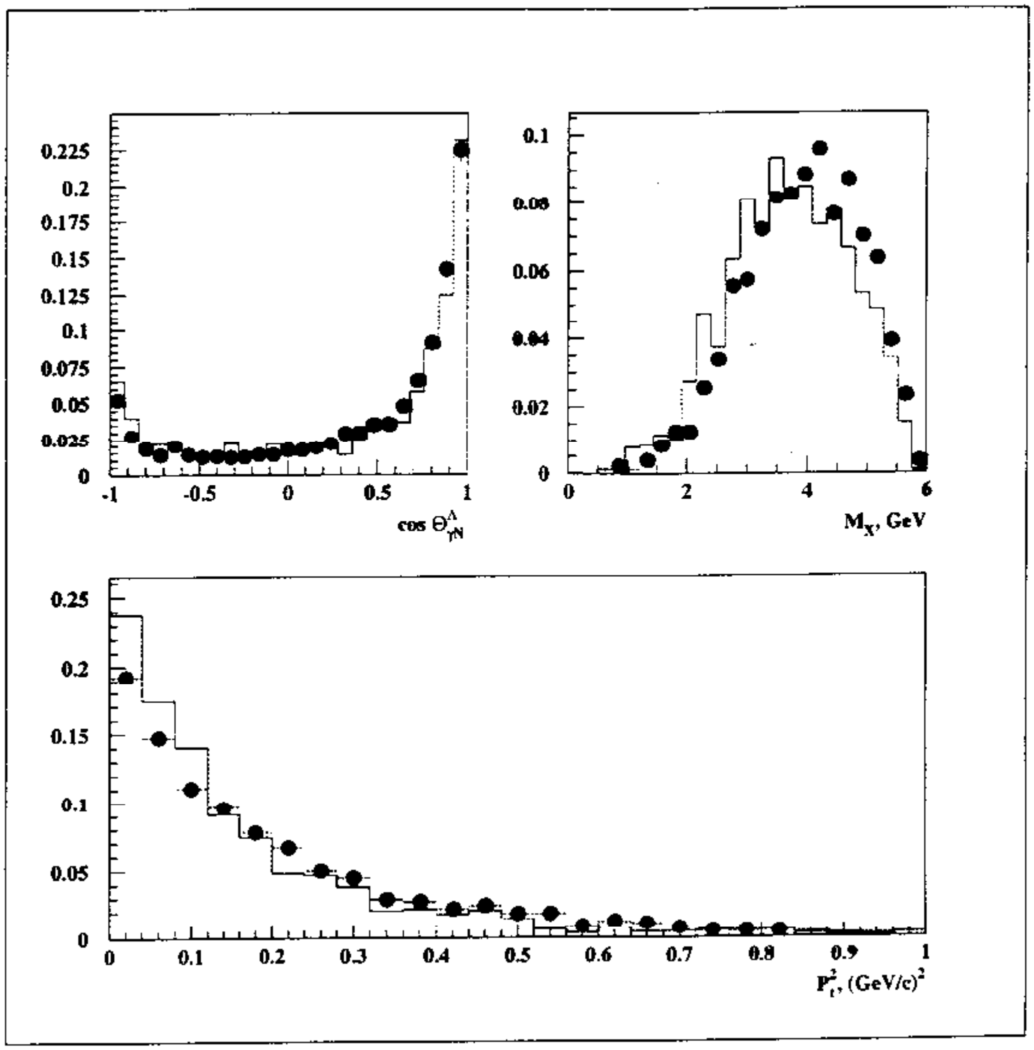
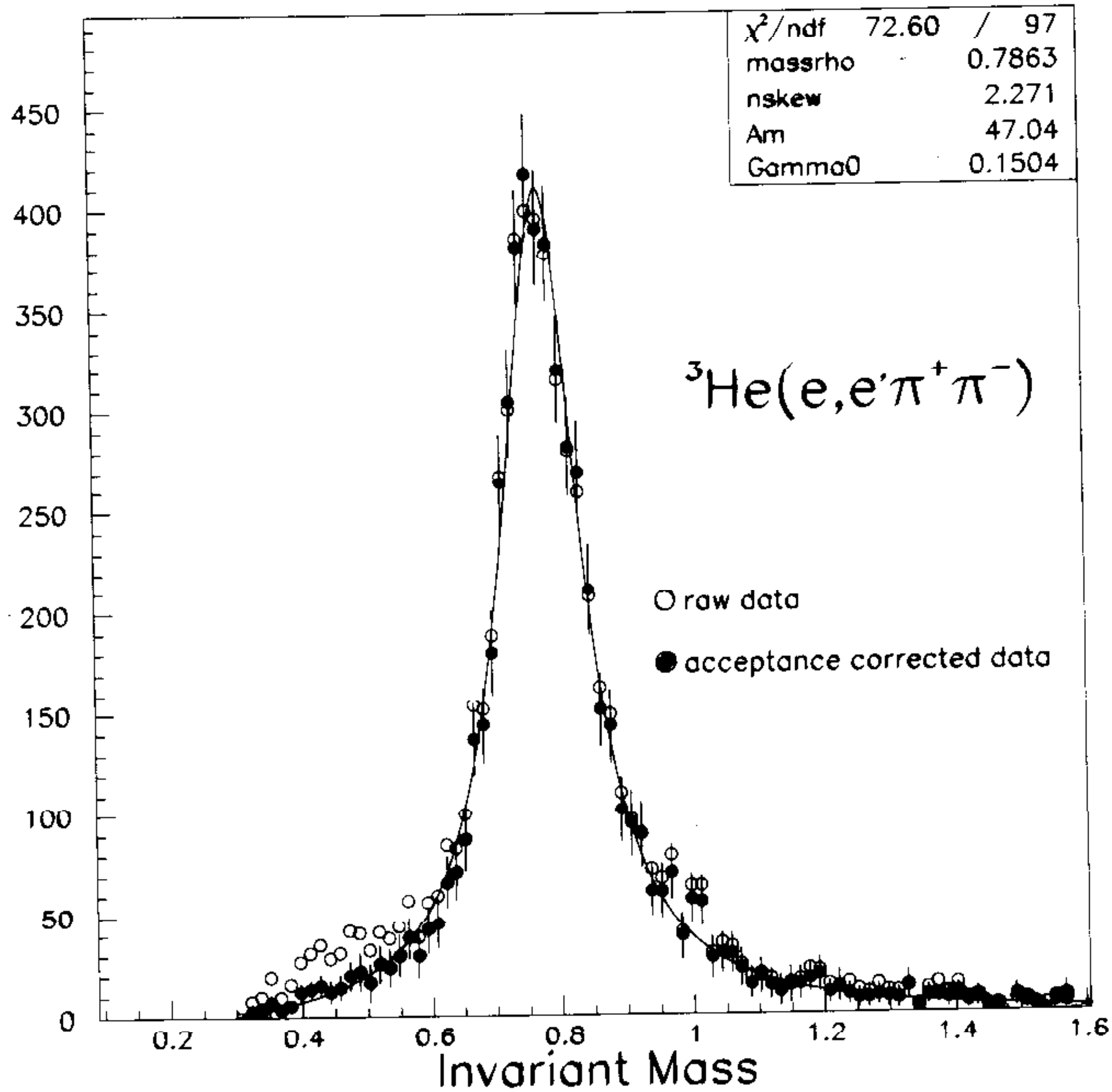
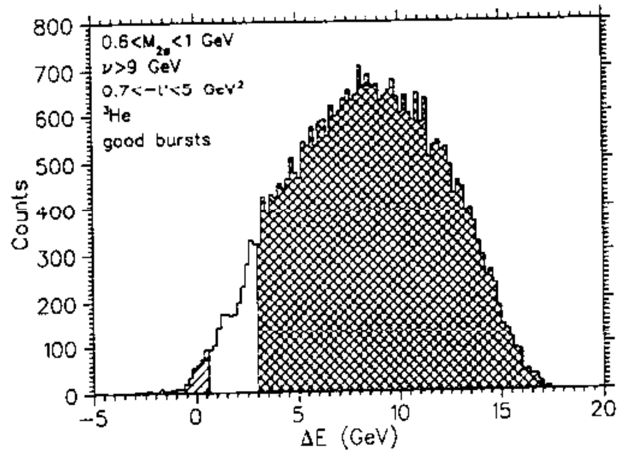


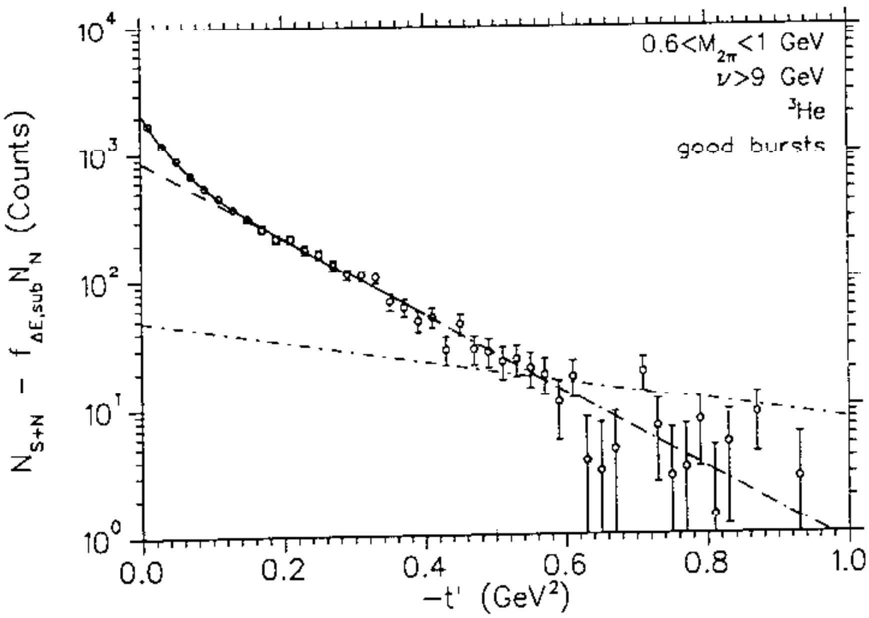
Figure 4: Comparison of normalized to unity experimental kinematic distributions(points) and HMC calculations(histograms).

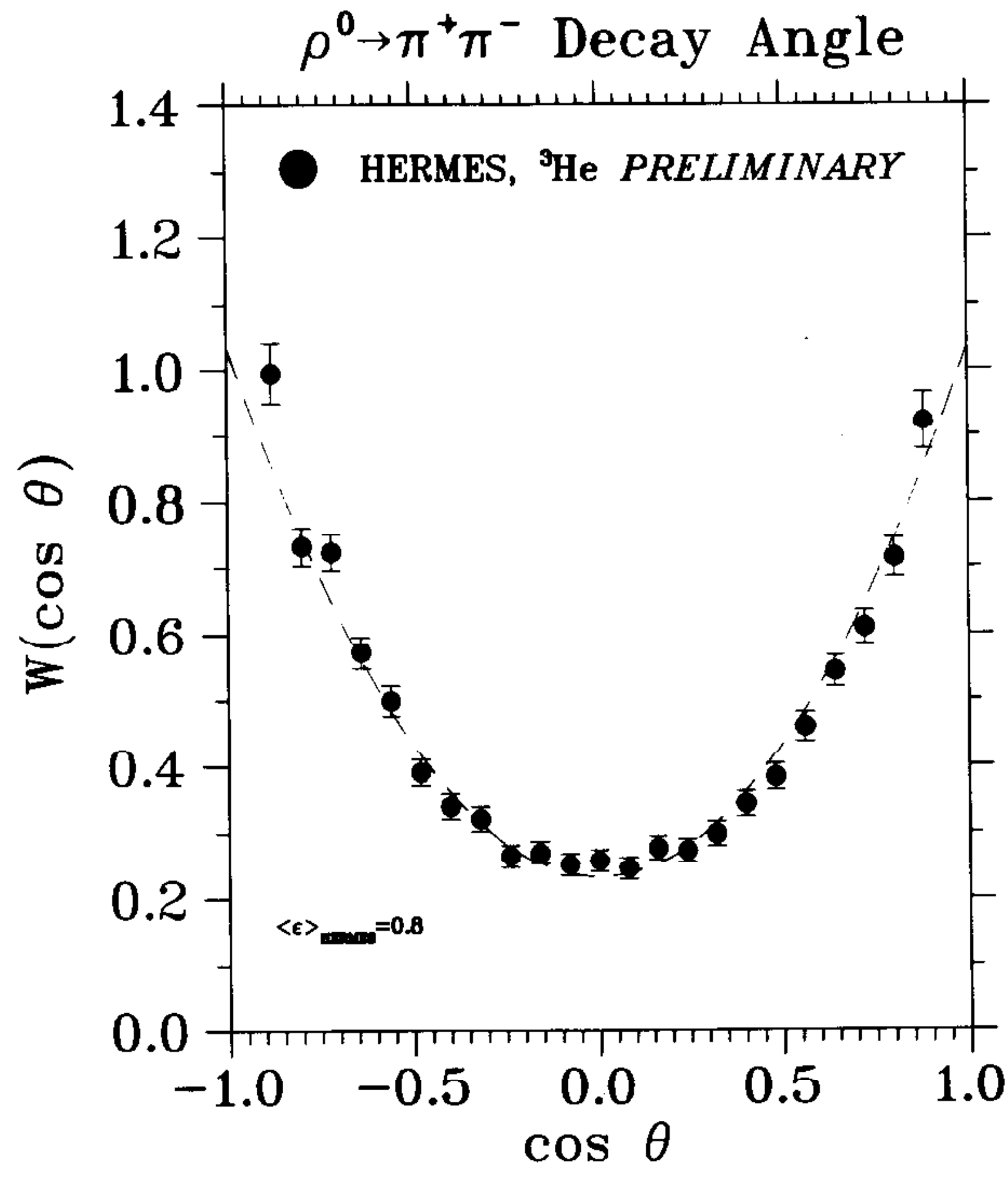
Rho



χ^2/ndf 72.60 / 97
massrho 0.7863
nskew 2.271
Am 47.04
Gamma0 0.1504
$^3He(e,e'\pi^+\pi^-)$
O raw data
● acceptance corrected data
0
50
100
150
200
250
300
350
400
450
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
Invariant Mass

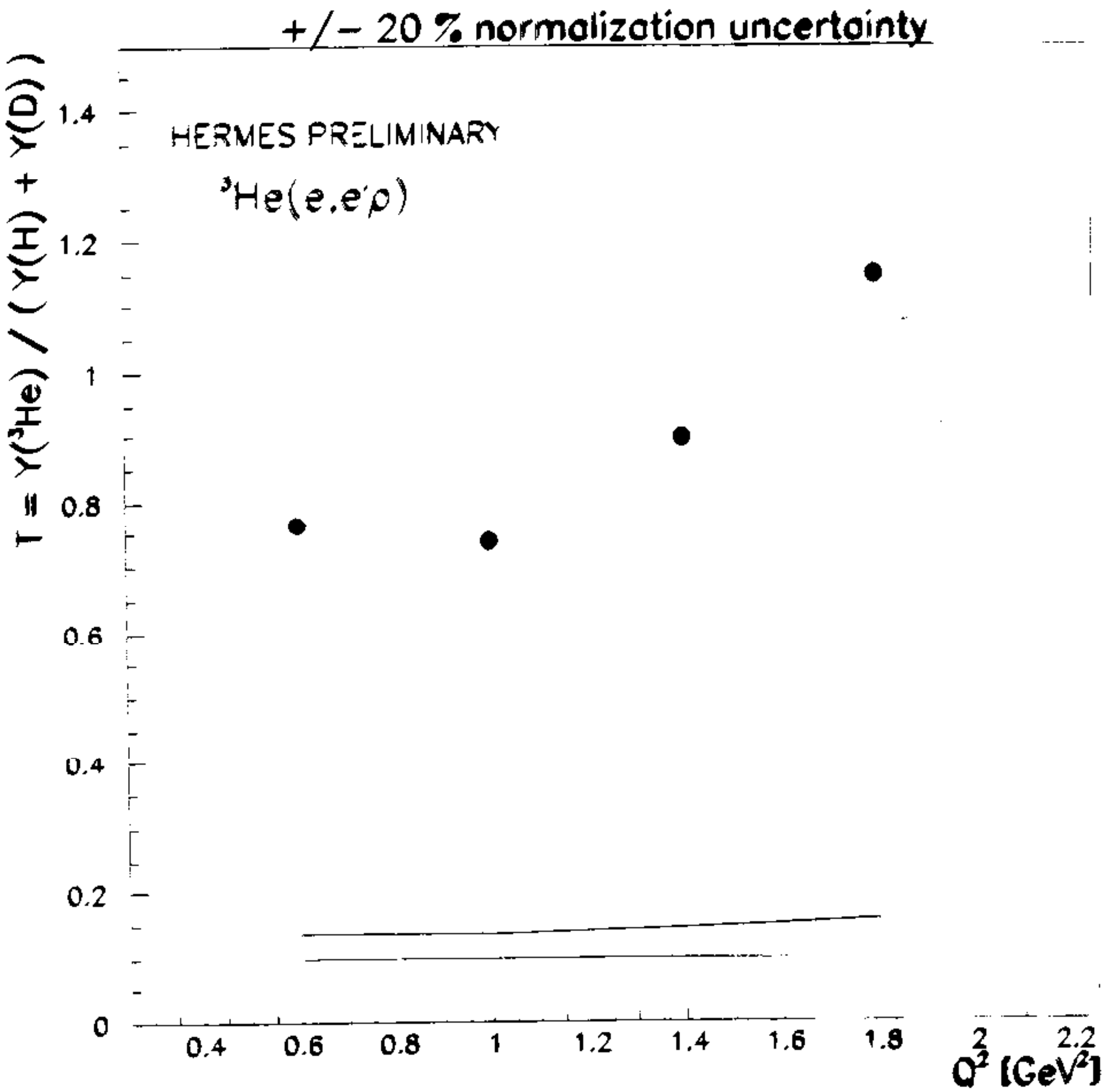

0.6<M<2π<1 GeV
ν>9 GeV
0.7<-t'<5 GeV²
³He
good bursts
Counts
ΔE (GeV)


0.6<M2π<1 GeV
ν>9 GeV
³He
good bursts
N S+N − f ΔE,sub N N (Counts)
−t' (GeV²)



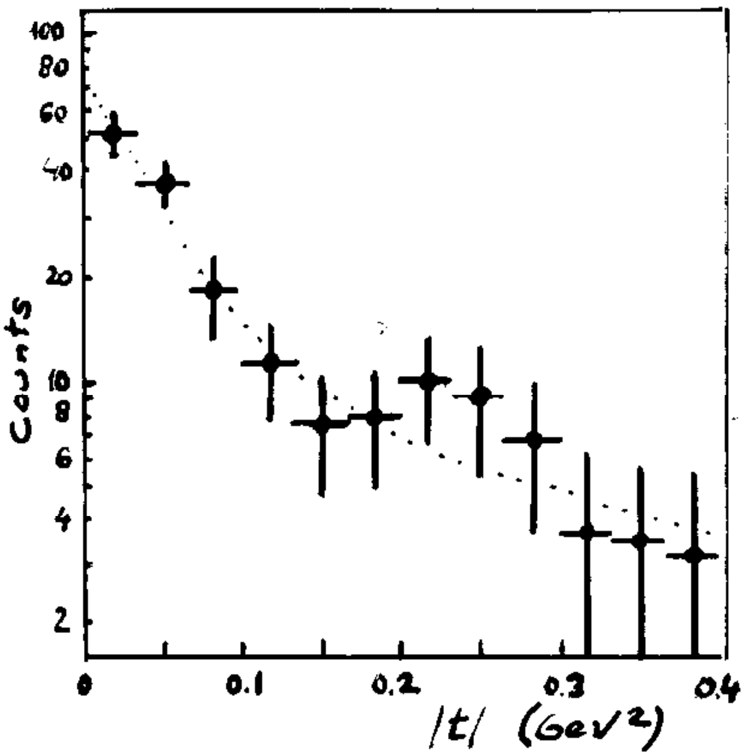
$\rho^0 \rightarrow \pi^+\pi^-$ Decay Angle
HERMES, ^{3}He *PRELIMINARY*
$<\epsilon>_{HERMES}$=0.8
W(cos θ)
cos θ
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−1.0
−0.5
0.0
0.5
1.0

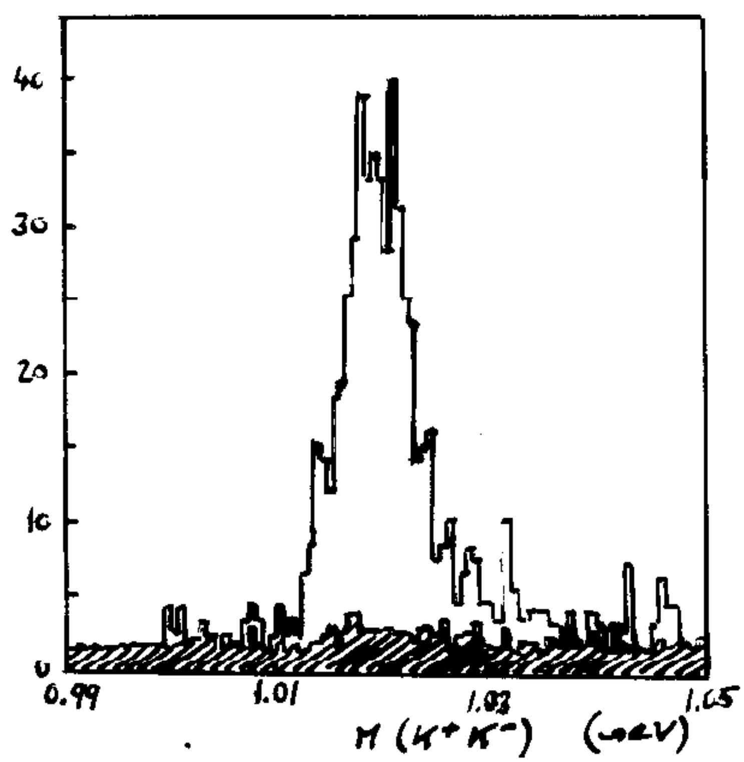
T. O'Neill - 1



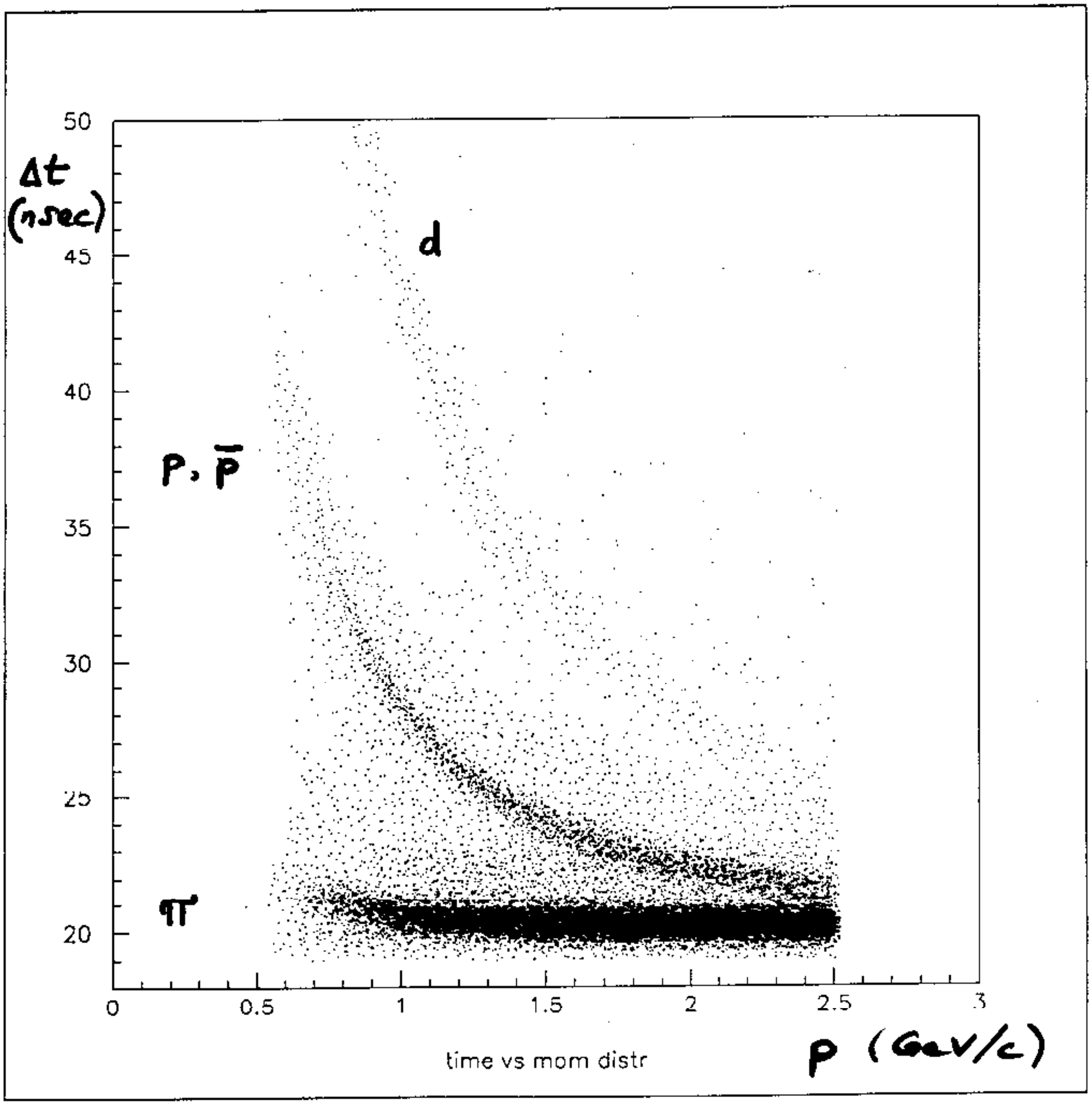
+/− 20 % normalization uncertainty
HERMES PRELIMINARY
³He(e,e′p)
T = Y(³He) / (Y(H) + Y(D))
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
Q² [GeV²]

Phi


Counts
100
80
60
40
20
10
8
6
4
2
0
0.1
0.2
0.3
0.4
|t| (GeV²)


40
30
20
10
0
0.99
1.01
1.03
1.05
M (K⁺K⁻) (GeV)

M. Amarian



TOF

Upgrade Plans for 98

1. Convert Threshold Cerenkov → RICH

   → Two Radiators:

   - 'Clear' Aerogel $n \sim 1.03$
   - plus C_4F_{10} gas

   → new mirrors

   → photon detector: ~ 4,000 P.M.'s
   0.75 in. dia

   momentum Coverage (GeV/c)

	Aerogel	Gas
K/π - Sep.	1-8	4-19
K/p - Sep.	2-14	10 - >25

2. Charm Physics Upgrade

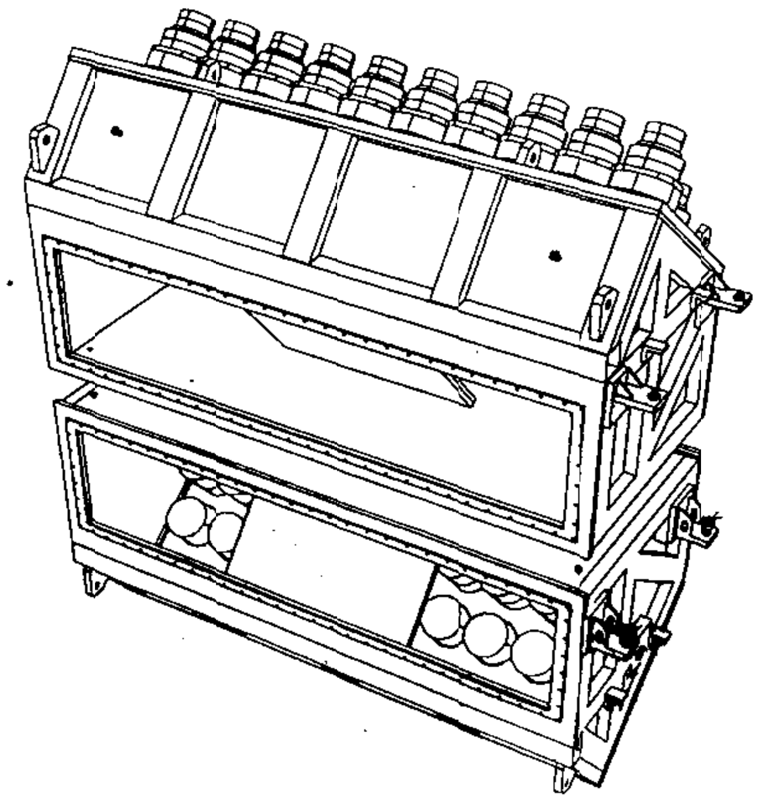
   → Iron Wall (muons!)

   → FQS (small angle spectrometer)

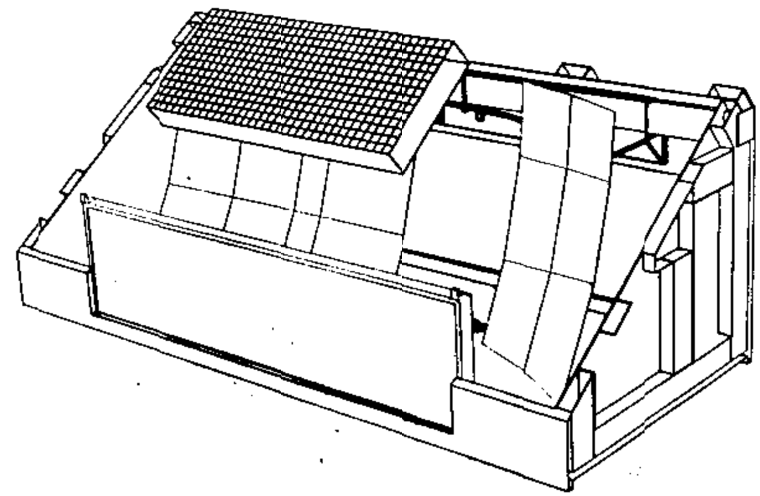
   → RICH (see above)

RICH Upgrade

HERMES RICH COUNTER



The threshold Cerenkov counter pair as presently configured in the HERMES spectrometer. The entrance window has been removed and all but a central section of the mirror backplane has been cut away to expose the phototube assemblies.



A cutaway schematic view of the proposed RICH counter. The entrance region is covered by a plane of Aerogel $5cm$ thick. A section of the spherical mirror has been cut away for display purposes. The photon detector is indicated by the canted rectangular volume above the sensitive region.

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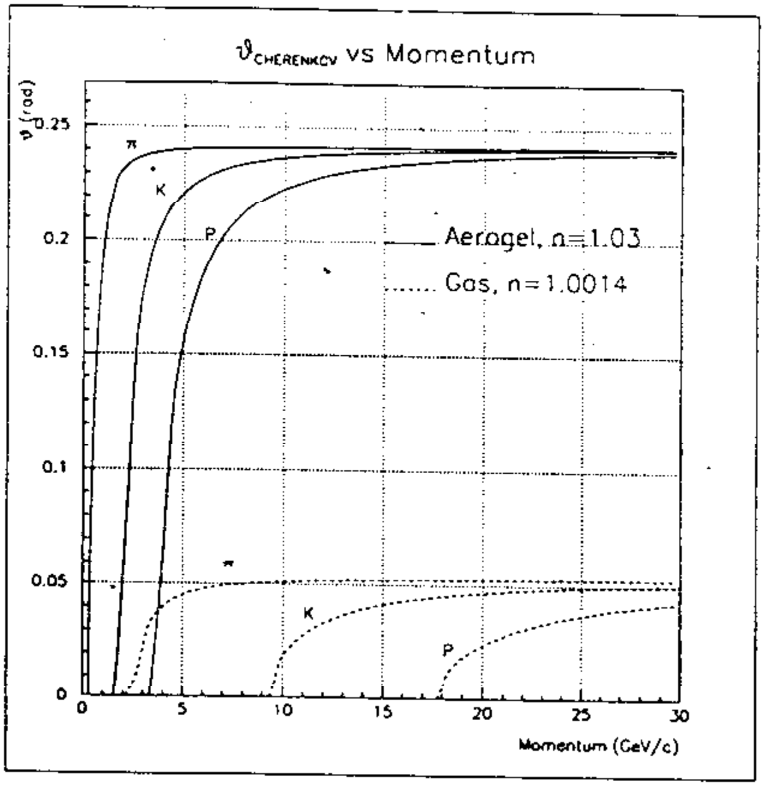
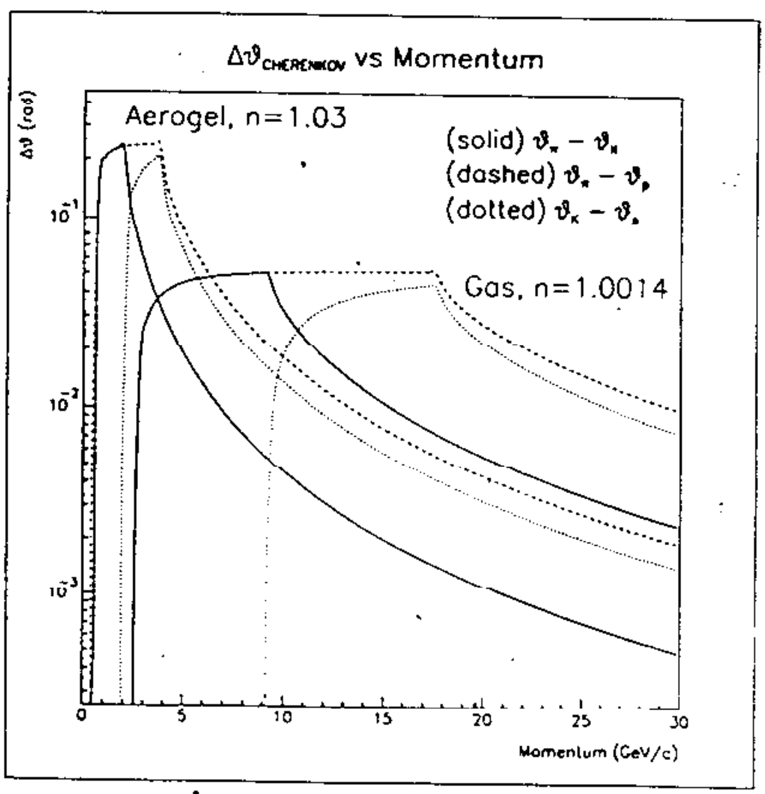
HERMES RICH

hermes





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HERMES RICH COUNTER

hermes

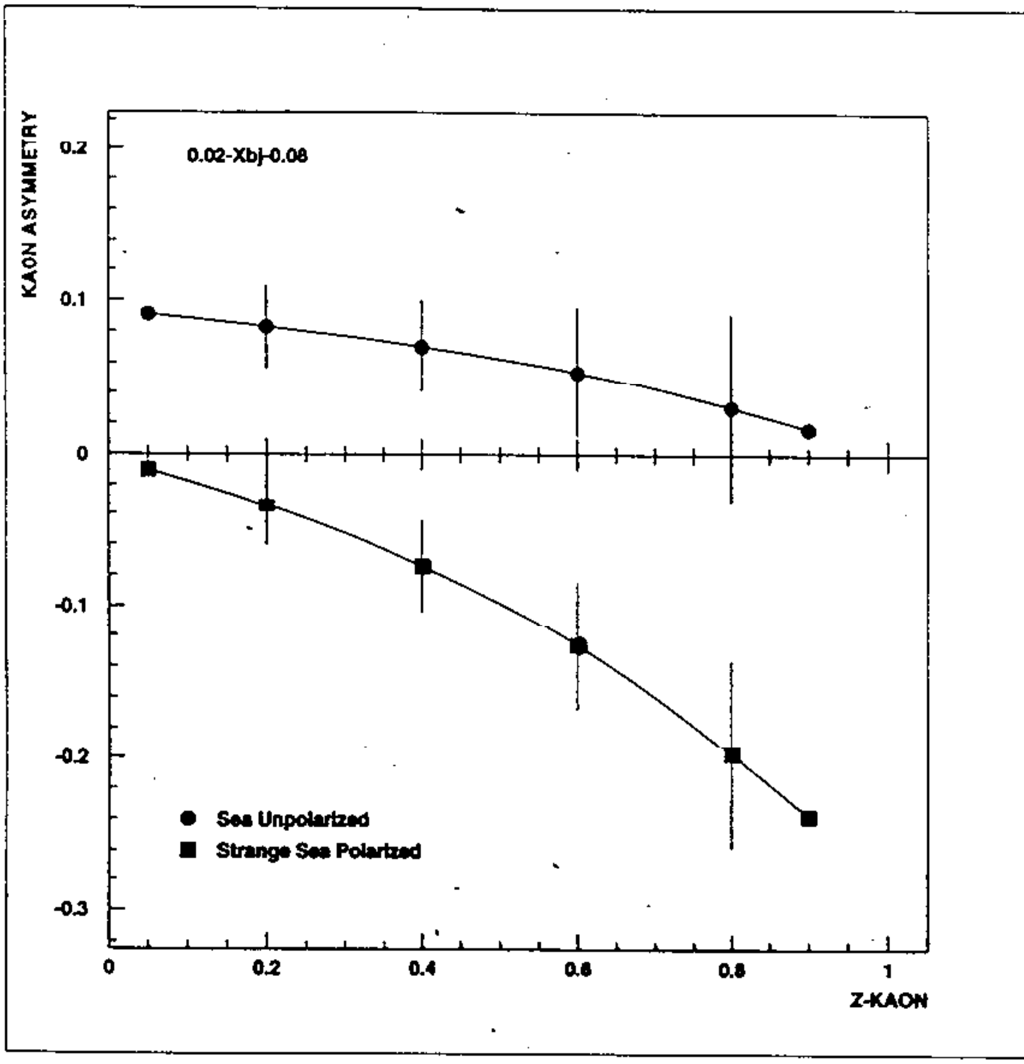

Figure 1: Results of a HMC Monte Carlo simulation of $A_p^{K^-}(z)$ for an unpolarized sea, and for a maximally negatively polarized strange sea, $(\Delta\overline{q} = 0.0, \Delta\overline{s} = -\overline{s})$ with $0.02 \geq x_{bj} \geq 0.08$. The error bars indicate the statistical precision with which $A_p^{\pi^-}$ would be measured in a standard HERMES run.

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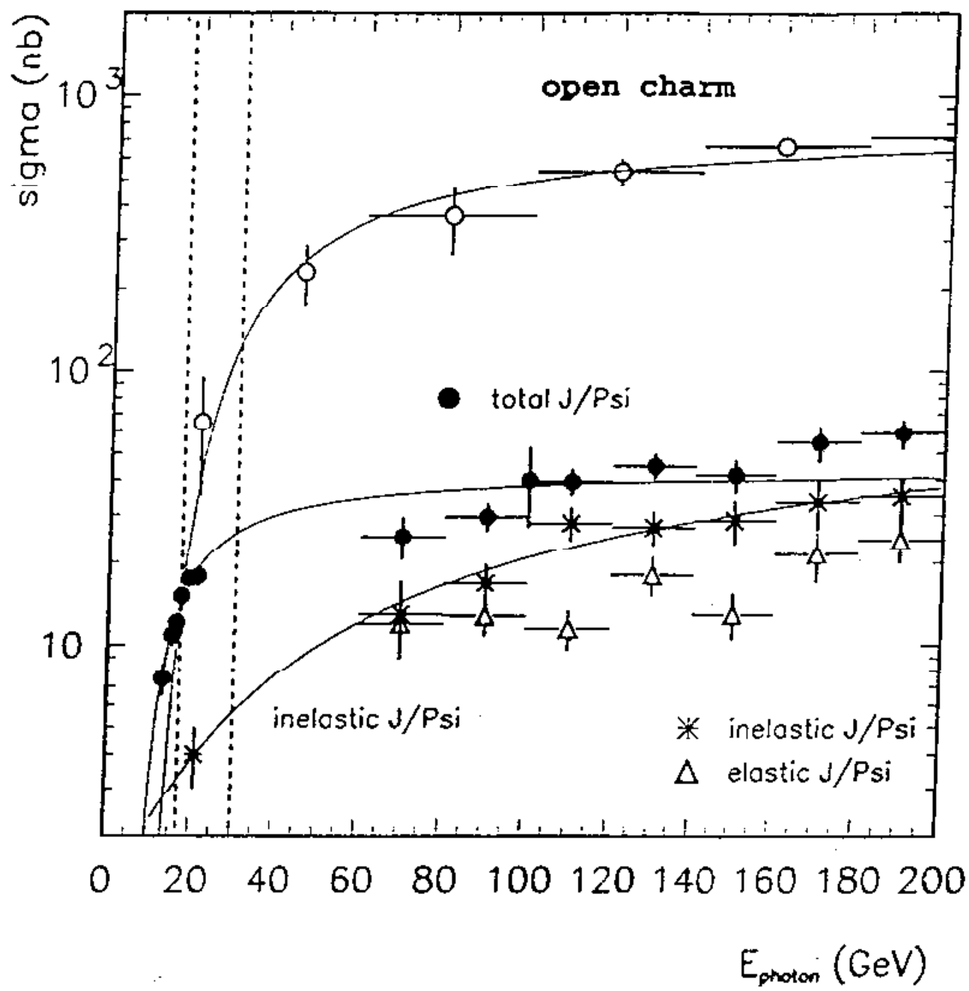
Charm Physics



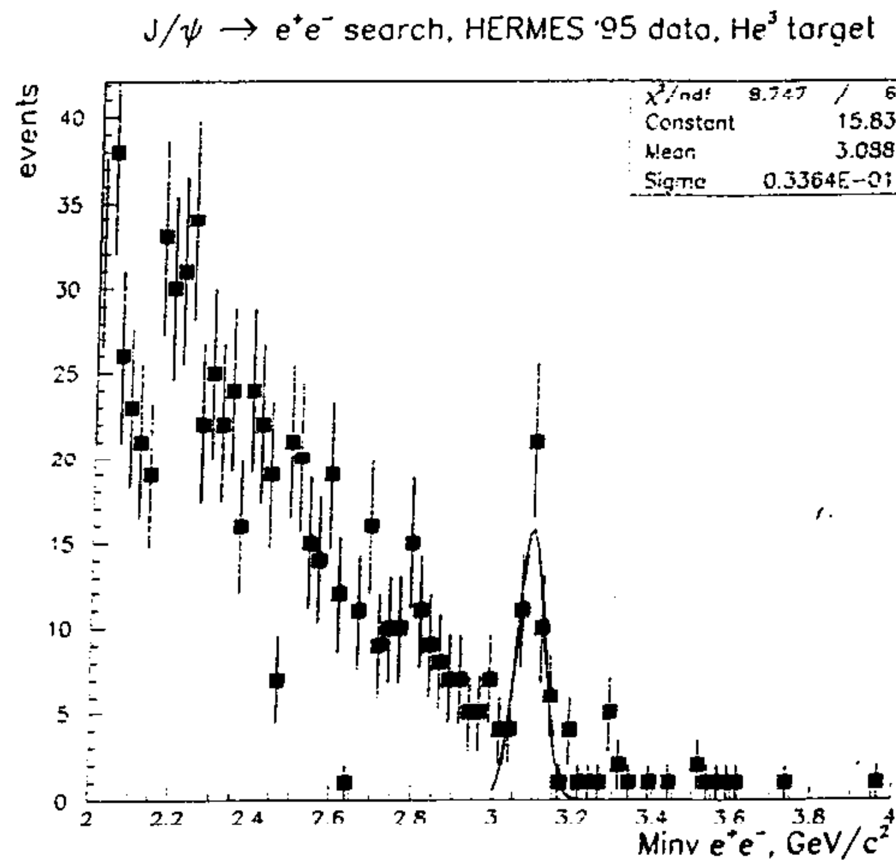
- cross sections for open charm and J/ψ production near threshold ?
- s channel helicity conservation in J/ψ production ?
- spin dependent charm production $\longrightarrow \Delta G/G$

Charm Physics

hermes

- clear J/ψ signal observed in 95 data
- cross section in agreement with other measurements
  BUT: uncertainty $\sim$ 50%
  no separation between different production mechanisms
  no sensitivity to ΔG (dilution factor of ^{3}He)

PRELIMINARY



Charm Physics

Observable decay modes

- open charm

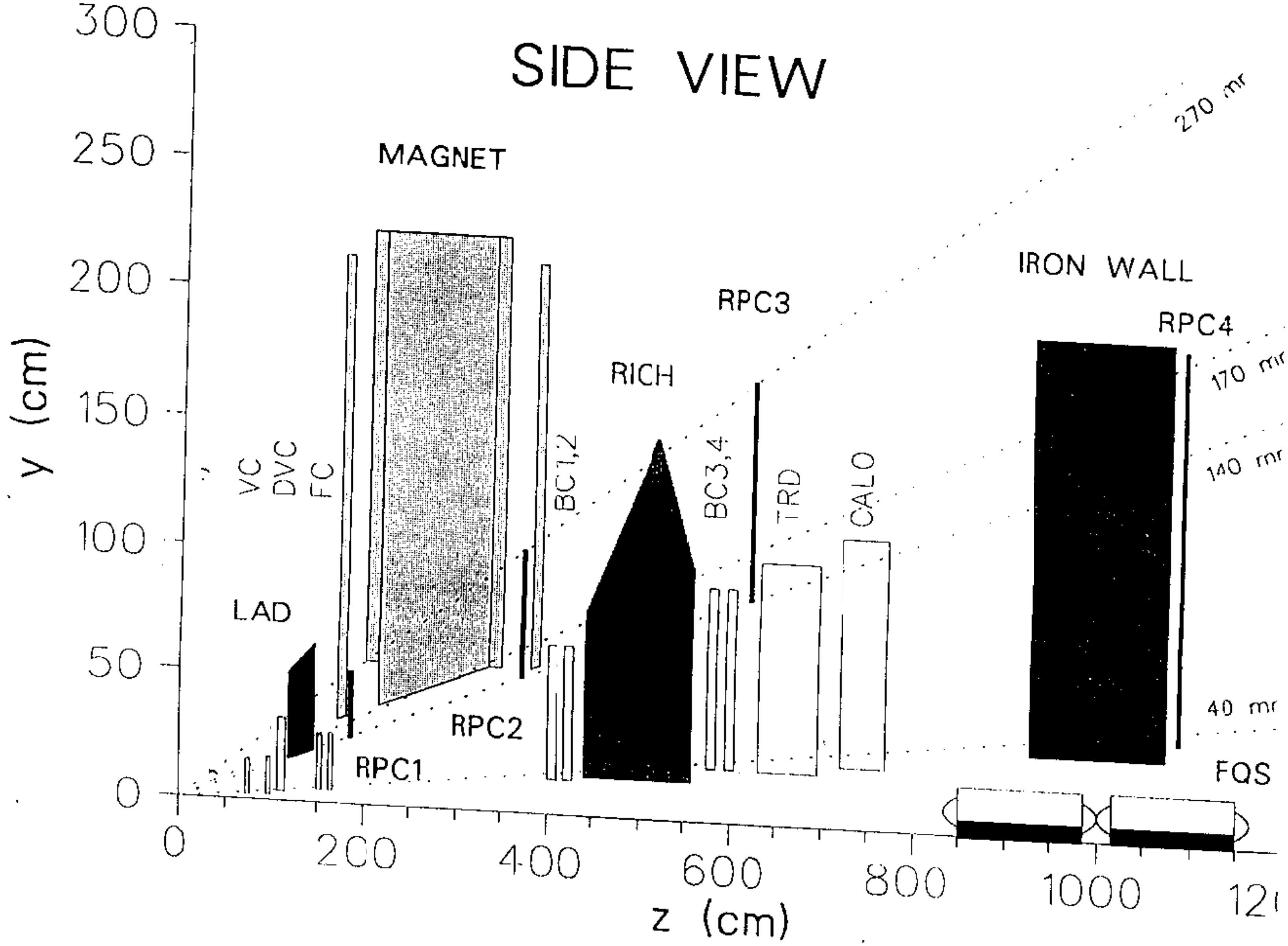
  $D^0 \longrightarrow K^+\pi^- \quad + \text{c.c.}$
  $D^0, D^+ \longrightarrow K^+\mu^- X \quad + \text{c.c.}$

  - requires very good PID RICH
  - suffers from large combinatoric background
  - $D^0 \longrightarrow K^+\pi^-$ is the only decay mode into 2 particles, i.e. has the best signal/background ratio
  - K and μ from the vertex is a clear signature for charm

- J/ψ

  $J/\psi \longrightarrow e^+e^-$
  $J/\psi \longrightarrow \mu^+\mu^-$

  - requires large acceptance
  - suffers from low rates
  - has almost no background


SIDE VIEW
MAGNET
IRON WALL
RPC3
RPC4
RICH
270 mr
170 mr
140 mr
40 mr
VC
DVC
FC
BC1,2
BC3,4
TRD
CALO
LAD
RPC1
RPC2
FQS
y (cm)
z (cm)
0
50
100
150
200
250
300
0
200
400
600
800
1000

Summary

- expect many semi-incl. results soon from 95 data
- soon also, preliminary results from 96 data
- 97 Run is in progress and should be very productive
- Major upgrades for 98