E.Steffens
University of Erlangen
DESY-PRC
May 17, 01

HERMES – where we are after Run-I

Run-I Polarized Targets 1995 $^3\overrightarrow{\mathrm{He}}$ 1996-97 $^1\overrightarrow{\mathrm{H}}$ 1998-2000 $^2\overrightarrow{\mathrm{D}}$

Inclusive DIS	$g_1^{p,n}(x)$	• quark polarization
Semi-incl. DIS	$\Delta q_f(x)$	in the nucleon
Unexpected:	ΔG „first quantitative estimate“	• gluon polarization
	azimuthal asymm. $A_{UL}(\Phi)$ for π-production	• transversity
More to come?	for real γ (DVCS)	• quasi-exclusive react.

Run-I Unpolarized Targets H_2, D_2, ^3He, ^4He, N_2, Ne, Kr

What is the hadron formation time? • nuclear effects

Unexpected: Ratio $R = \sigma_L / \sigma_T$ in nuclei

E.Steffens-
University
of Erlangen

HERMES Status Report: Outline

hermes

1. Some recent results of Run-I

Δq_f, $A_{UL}(\Phi)$, DVCS, nucl. effects, ...

2. Future plans

2001-2002	- transv. pol. $\vec{H}$-target
	- high-density unpol. targets
2003	- continue (?)
2004 -	- high-density unpol. targets and Recoil Detector (addendum to Si proposal)
?	- long. pol. $\vec{H}$-target (1st measurement with RICH)

3. Conclusions

E.Steffens-
University
of Erlangen

DESY-PRC
May 17, 01

Quark Polarization Δq_f from Semi-incl. Measurements I

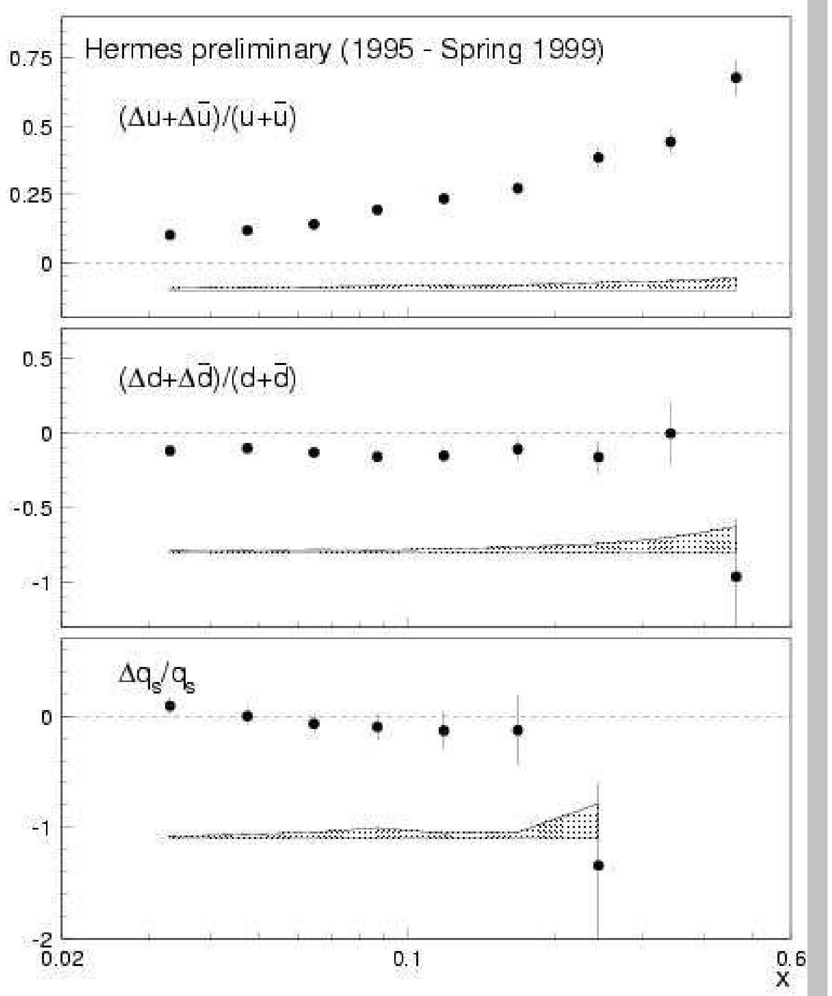
- Central task of HERMES!
- Published results on 95 - 97 data

  $\vec{H} = \vec{p}$ and ${}^3\vec{He} \sim \vec{n}$
- New: large 98 – 2000 $\vec{D}$ data set

  $\vec{n} \sim \vec{D} - \vec{H}$ (less nucl. corrections)

<u>Released</u>

Δq_f from 95 – spring 99 data



Quark Polarization Δq_f from Semi-incl. Measurements II

Full 98 – 2000 $\vec{D}$ data set:

b-production done!

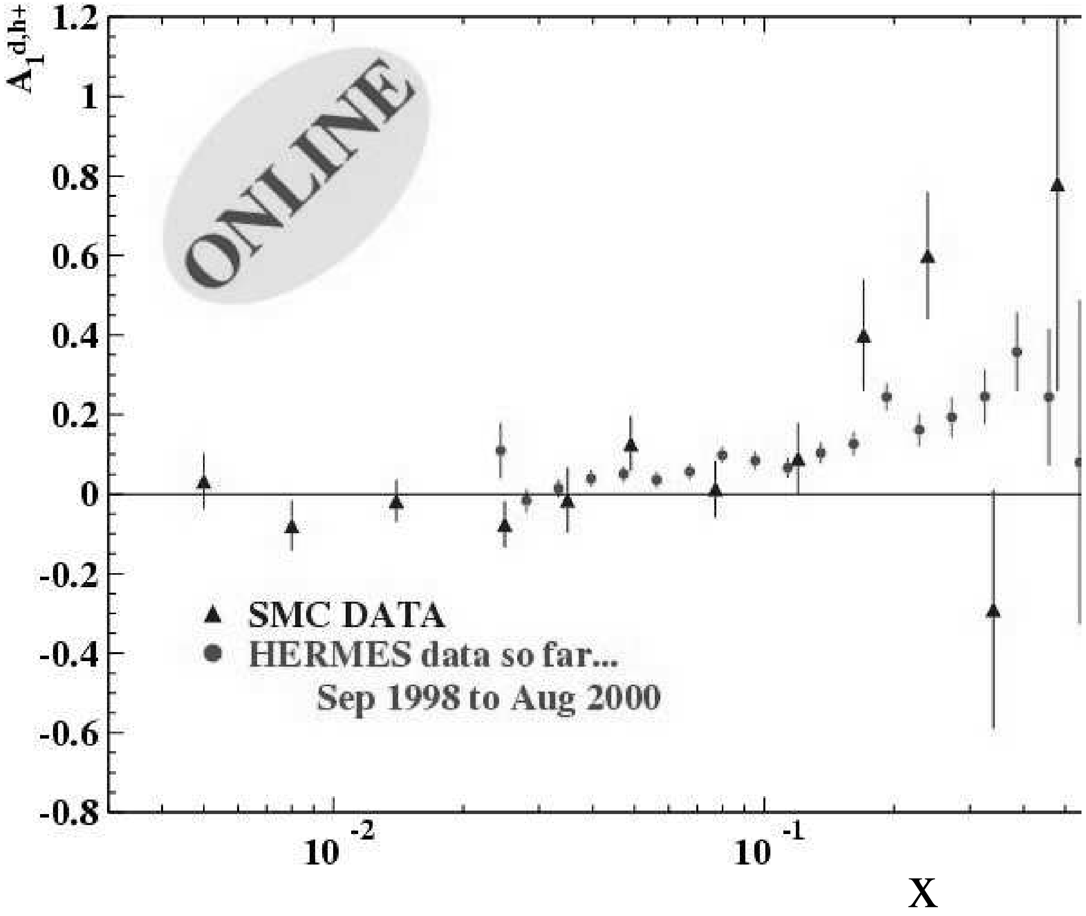
–> online h^+ asymmetry

Analysis in progress!

- $\pi^{\pm}$ asymmetries

- $K^{\pm}$ asymmetries

  (–> strange sea ?)



E.Steffens-
University
of Erlangen

Quark Polarization Δq_f from Semi-incl. Measurements III

Data and Projections

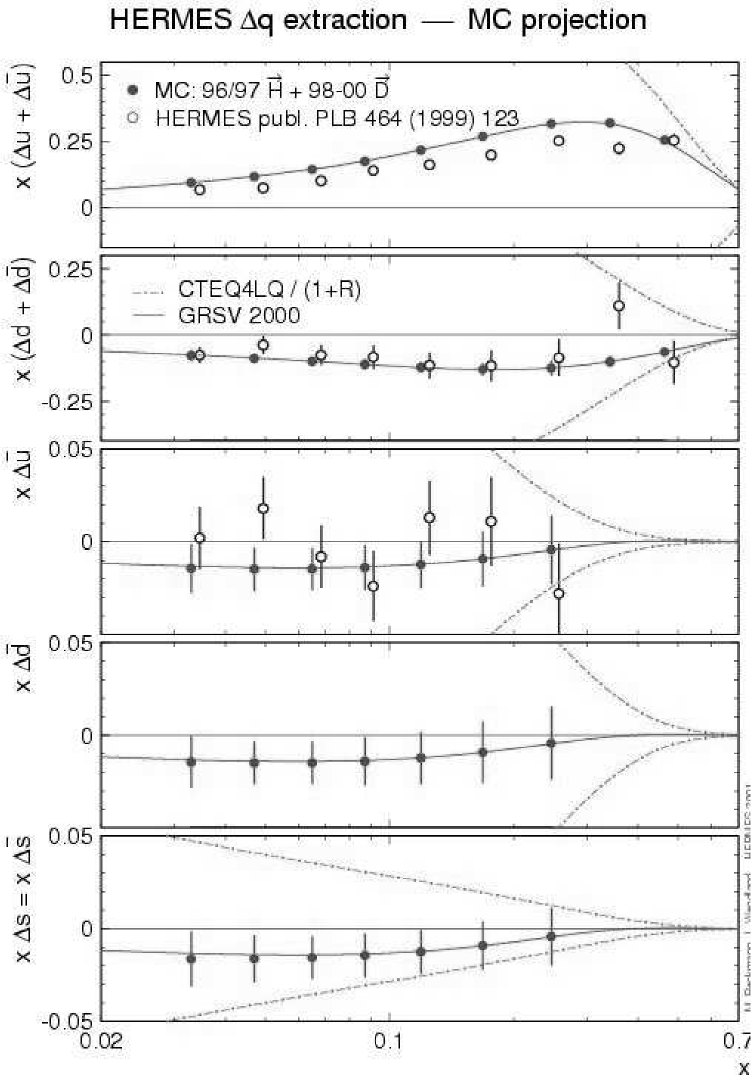
hermes

Published data (-97)
PLB **464** (1999) 123

Project.for existing
data set (96-2000)

Strong improvement
on d-quark pol. and
non-strange sea!

First significant
measurement of
strange sea (scale!)
can be expected.



- Semi-incl. data will provide an entirely new view of the nucleon spin structure $\Delta q_f\,(x, Q^2)$
- Next: transverse spin structure $\delta q_f\,(x, Q^2)$ by using a transverse target

$$q_f = u$$
$$\quad\; d\ ?$$

First glimps on transversity:

Azimuthal π asymmetries!

E.Steffens-University of Erlangen

DESY-PRC May 17, 01

Single-Spin Azimuthal Asymmetries A_{LU}, $A_{UL}(\Phi)$ I

hermes

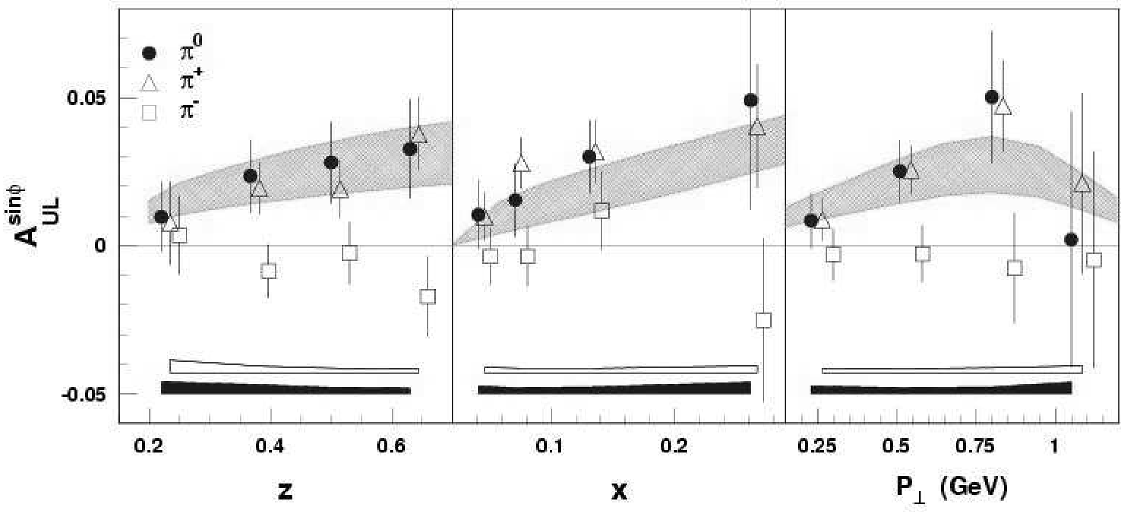
$A_{\text{Beam Target}}(\Phi)$

L = long. polarized U = unpol.

Φ = azimuthal angle around γ^* wrt. hadron plane π SSAA

wrt. real photon plane DVCS

A_{UL} beam spin averaged, with target polarization (density limited)



- $\sin\Phi$ moment as function of z, x and p_T
- Sign. effect for π^+ and π^0, small effect for π^-
- Sensitive to transverse pol. of fragmenting quark

First exp. result on „transversity“!

PRL 84 (2000) 4047 $\pi^\pm$

hep-ex/0104005 π^o

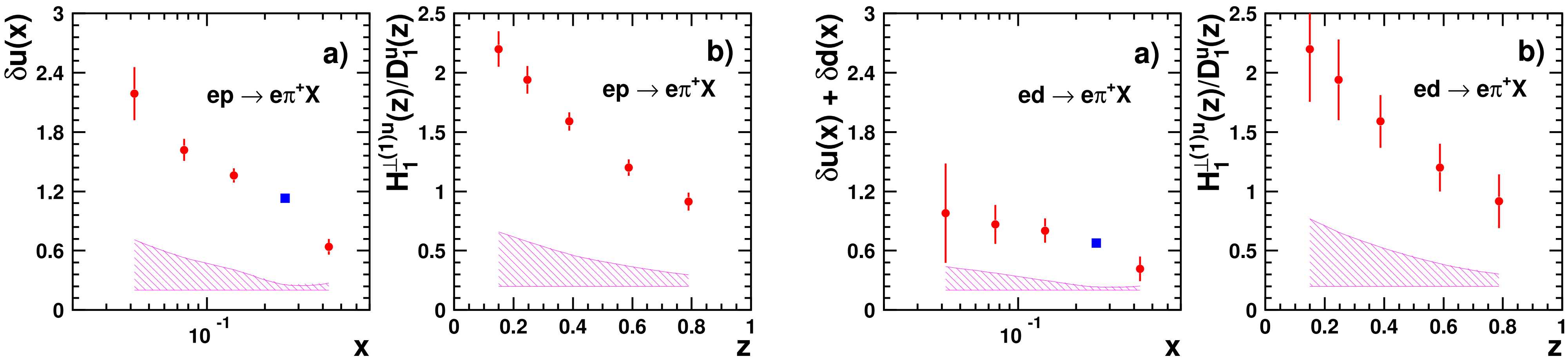
A_{LU} target spin averaged, with beam polarization

High density unpol. targets → up to 100x higher luminosity!

TRANSVERSITY THROUGH THE COLLINS EFFECT: PROSPECTS

OPTION 1: PROTON TARGET
PROJECTIONS FOR $\delta u(x)$
AND $H_1^{\perp(1)u}(z)/D_1^u(z)$

OPTION 2: DEUTERON TARGET
PROJECTIONS FOR $\delta u(x) + \delta d(x)$
AND $H_1^{\perp(1)u}(z)/D_1^u(z)$



$\Rightarrow$ HERMES CHOSE OPTION 1 FOR 2001+

NOTE: δd EXTRACTION POSSIBLE BY adding OPTION 2 ($\rightarrow$ COMBINED ANALYSIS)

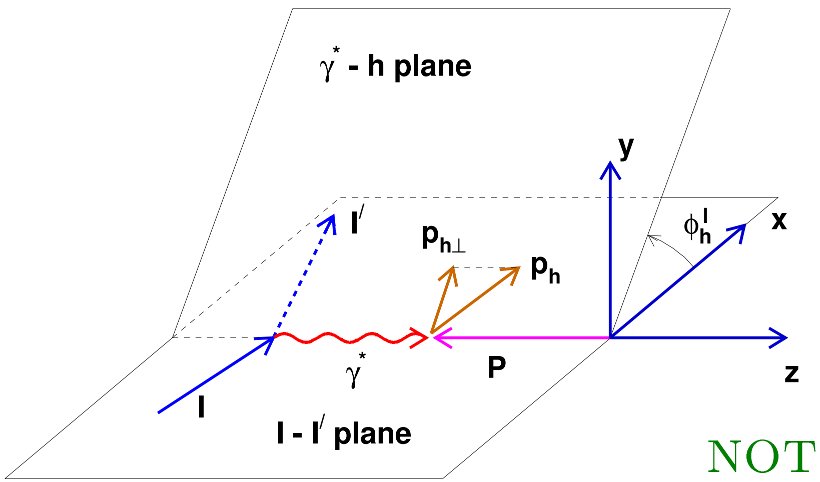
TRANSVERSITY THROUGH THE COLLINS EFFECT: METHOD

WEIGHTED ASYMMETRY

[MULDERS, TANGERMANN 96, KOTZINIAN, MULDERS 97]

$$A_T(x,y,z) \equiv \frac{\int d\phi^\ell \int d^2P_{h\perp} \frac{|P_{h\perp}|}{zM_h} \sin(\phi_s^\ell + \phi_h^\ell)\ (d\sigma^\uparrow - d\sigma^\downarrow)}{\int d\phi^\ell \int d^2P_{h\perp}(d\sigma^\uparrow + d\sigma^\downarrow)}$$

ϕ_s^l IS AZIMUTHAL ANGLE OF TARGET SPIN VECTOR W.R.T. γ^* AXIS



FACTORIZATION w.r.t. x AND z:

$$A_T(x,y,z) = f \cdot P_T \cdot D_{nn} \cdot \frac{\sum_q e_q^2\ \delta q(x)\ H_1^{\perp(1)q}(z)}{\sum_q e_q^2\ q(x)\ D_1^q(z)}$$

$D_{nn} = (1-y)/(1-y+y^2/2)$: TRANSVERSE SPIN TRANSFER COEFFICIENT

NOTE: $H_1^{\perp(1)q}$ ACCESSIBLE FROM e^+e^- DATA (LEP,BELLE)

E.Steffens-
University
of Erlangen

Nuclear Effects: Hadron Formation Time

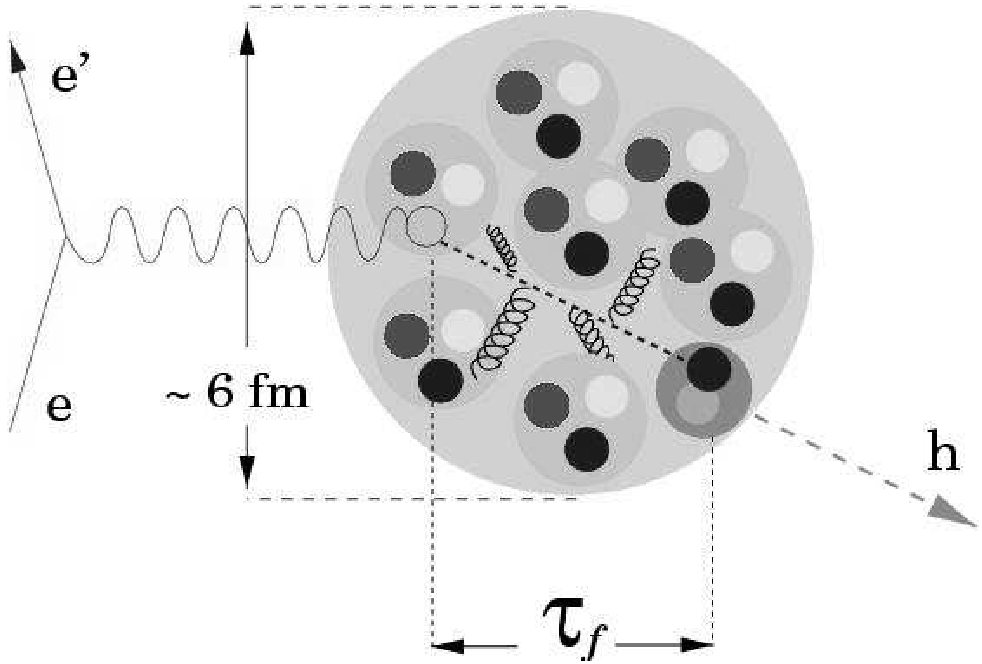
- Nuclear effects are identified by comparing cross-sections for heavy nuclei and deuterons (normalized to DIS rate).

$\rightarrow$ $R = \sigma_{heavy} / \sigma_{deut} \neq 1$

- A hadron is formed from a struck quark within a certain formation time τ_f. Those hadrons should be attenuated more in an extended nucleus compared with a deuteron.

$\rightarrow$ measure ratio R_A of hadron multiplicities on A and D !

If $R_A(h_1) < R_A(h_2) \Rightarrow \tau_f(h_1) < \tau_f(h_2)$!



Result: Comparison of formation times for different hadrons!

E.Steffens-
University
of Erlangen

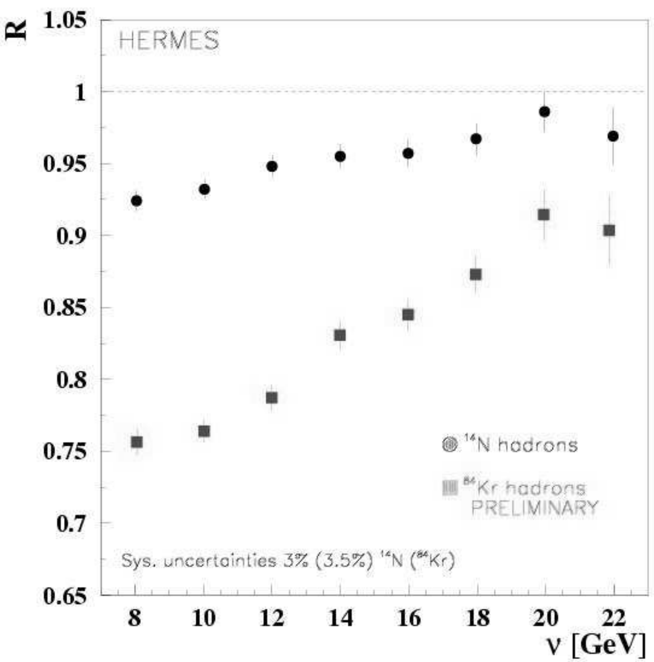
DESY-PRC
May 17, 01

Nuclear Effects: Hadron Attenuation in Nuclei

R(ν) = ratio of hadron multiplicities

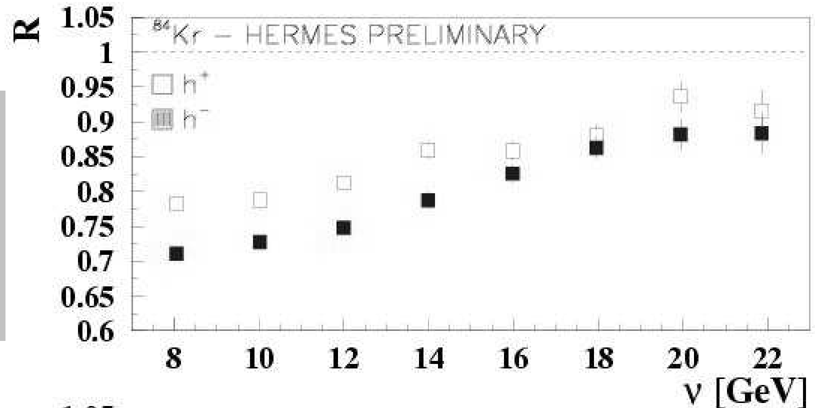
Existing result for Nitrogen (A=14) compared with new Krypton data (A = 84)

$\mathbf{R_N > R_{Kr}}$

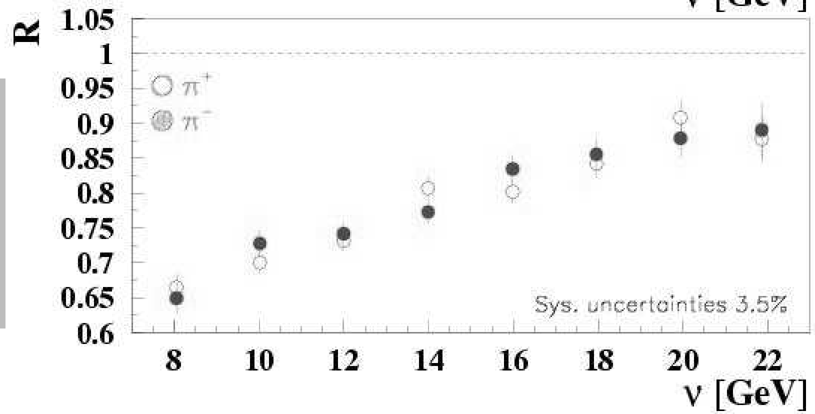


Ratios for $h^\pm$ and $\pi^\pm$ show different behavior, probably due to difference for protons and antiprotons. → p and K ratios coming soon!

marked difference for h^+ and h^-



no sign. difference for π^+ and π^-



E.Steffens-University of Erlangen

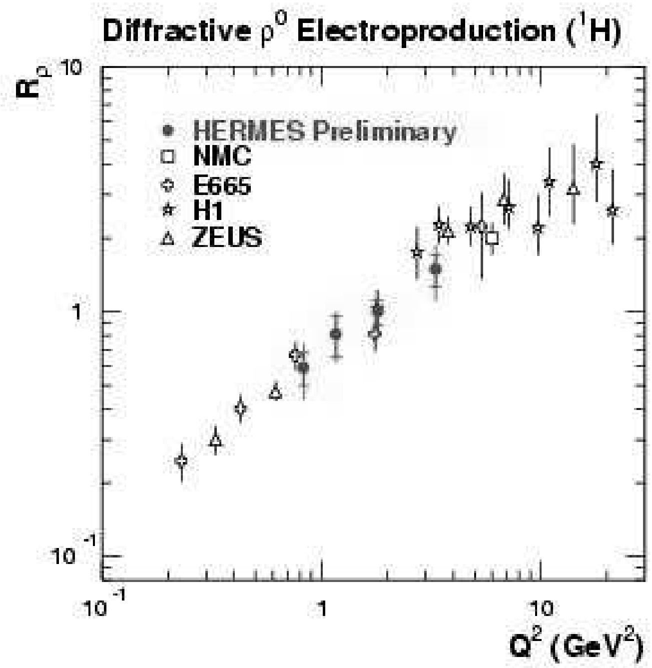
DESY-PRC
May 17, 01

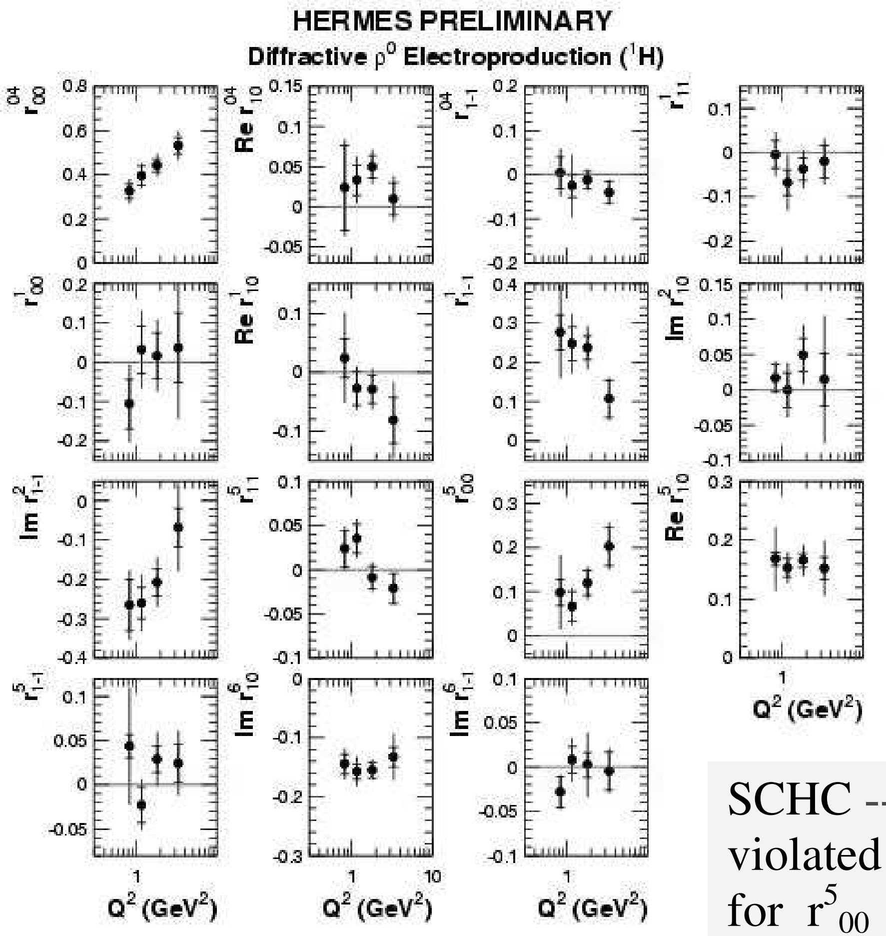
Diffractive ρ^0 Electroproduction on H Target

hermes

$R = \sigma_L / \sigma_T$
determined from r^{04}_{00}

good agreement with other HERA experiments (plus NMC & E665)



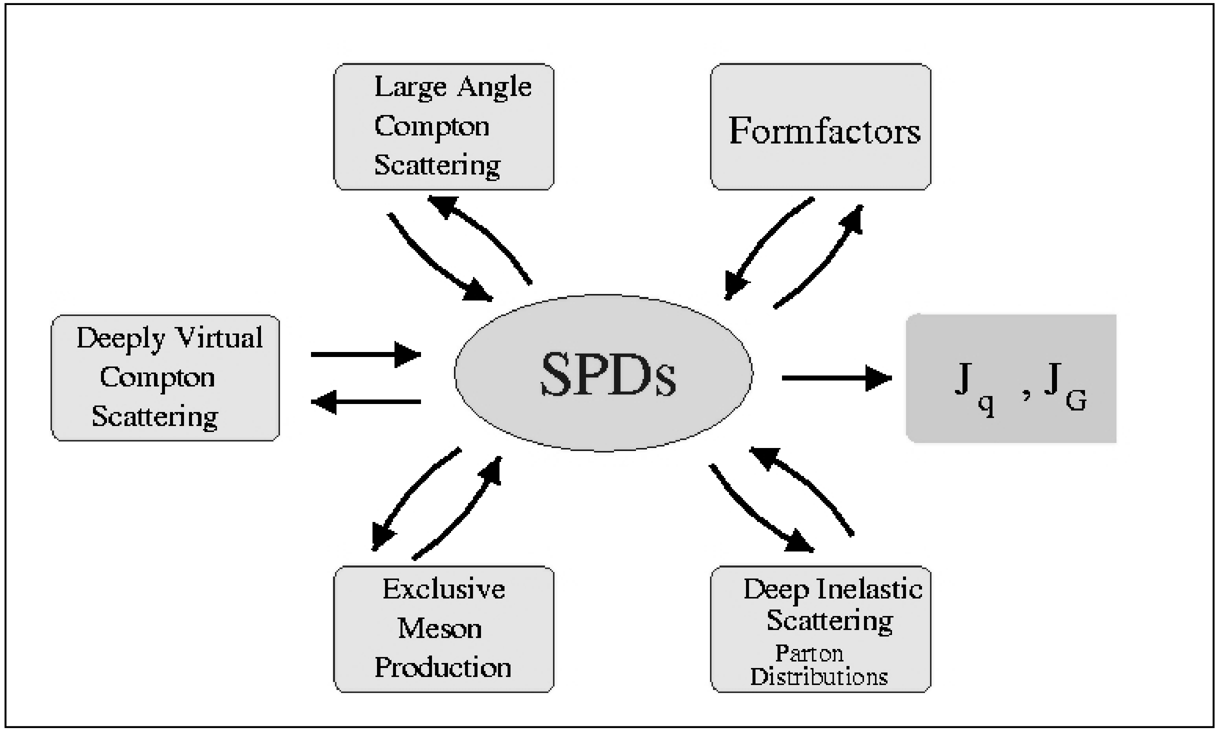


SCHC ---- violated for r^5_{00}

(Generalized) Skewed Parton Distributions

In general four SPDs exist for each quark flavor q, e.g. $H^q(x,\xi,t)$, $E^q(x,\xi,t)$. The variables are

- light-cone momentum fraction x
- *skewedness* parameter ξ
- momentum transfer t



These new distributions have the usual parton distributions as limiting cases. Via their first moments they are related to formfactors etc.

SPDs can be measured via various exclusive reactions. The cleanest channel may be DVCS. Other channels are hard excl. electro-production of pseudoscalar or vector mesons.

The HERMES result on DVCS and „exclusive“ π^+ is a first step towards the measurement of SPDs.

E.Steffens-
University
of Erlangen

DESY-PRC
May 17, 01

Deeply-Virtual Compton Scattering

(1997 data)

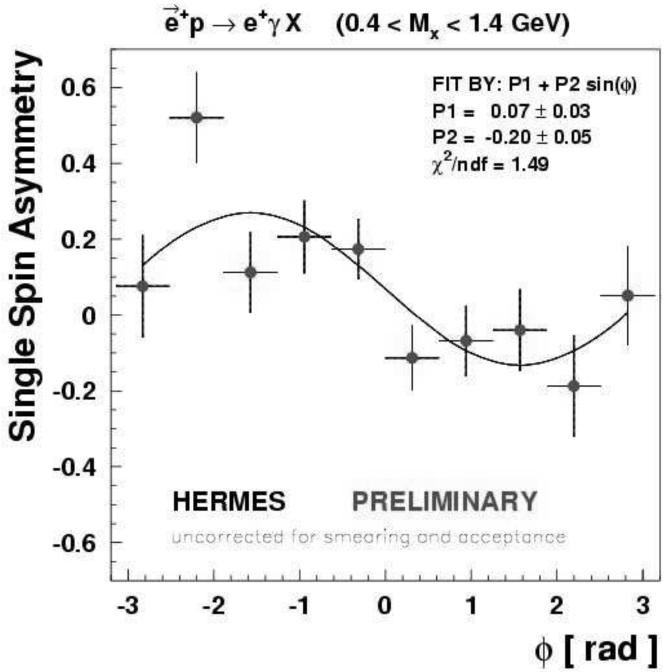
- Beam-spin asymmetry $A_{LU}(\Phi)$ in hard electro-production of real γ.
- Interference between DVCS and Bethe-Heitler process gives rise to $\sin(\Phi)$ term wrt. lepton plane.

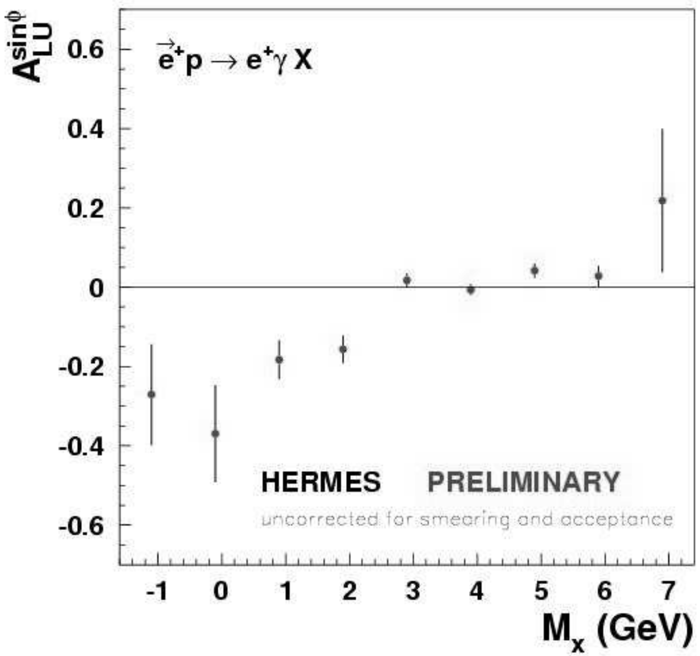
$A_{LU} = \sin(\Phi)$ moment as function of missing mass M_x

(due to limited M_x resolution the signal is smeared out and extends to negative masses)

$A_{LU}^{\sin(\Phi)} = -0.23 \pm 0.04 \quad (M_x < 1.7 \text{ GeV})$

A_{LU}

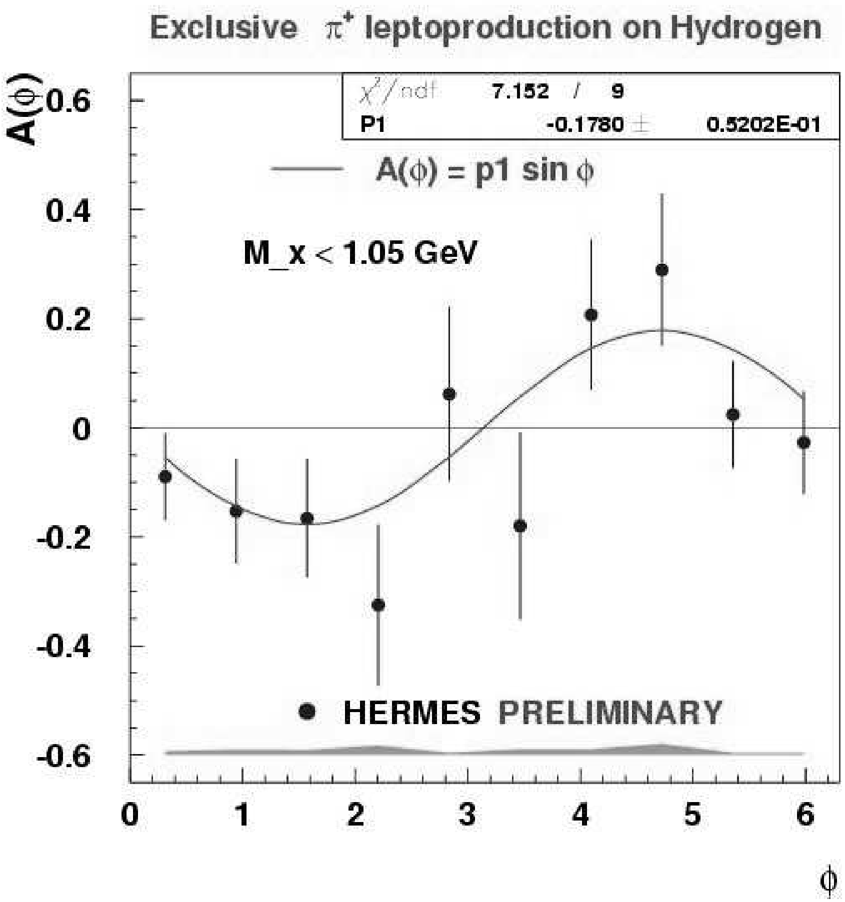




E.Steffens-
University
of Erlangen

DESY-PRC
May 17, 01

Single-Spin Azimuthal Asymmetry $A_{UL}(\Phi)$ for π^+ production in the exclusive limit



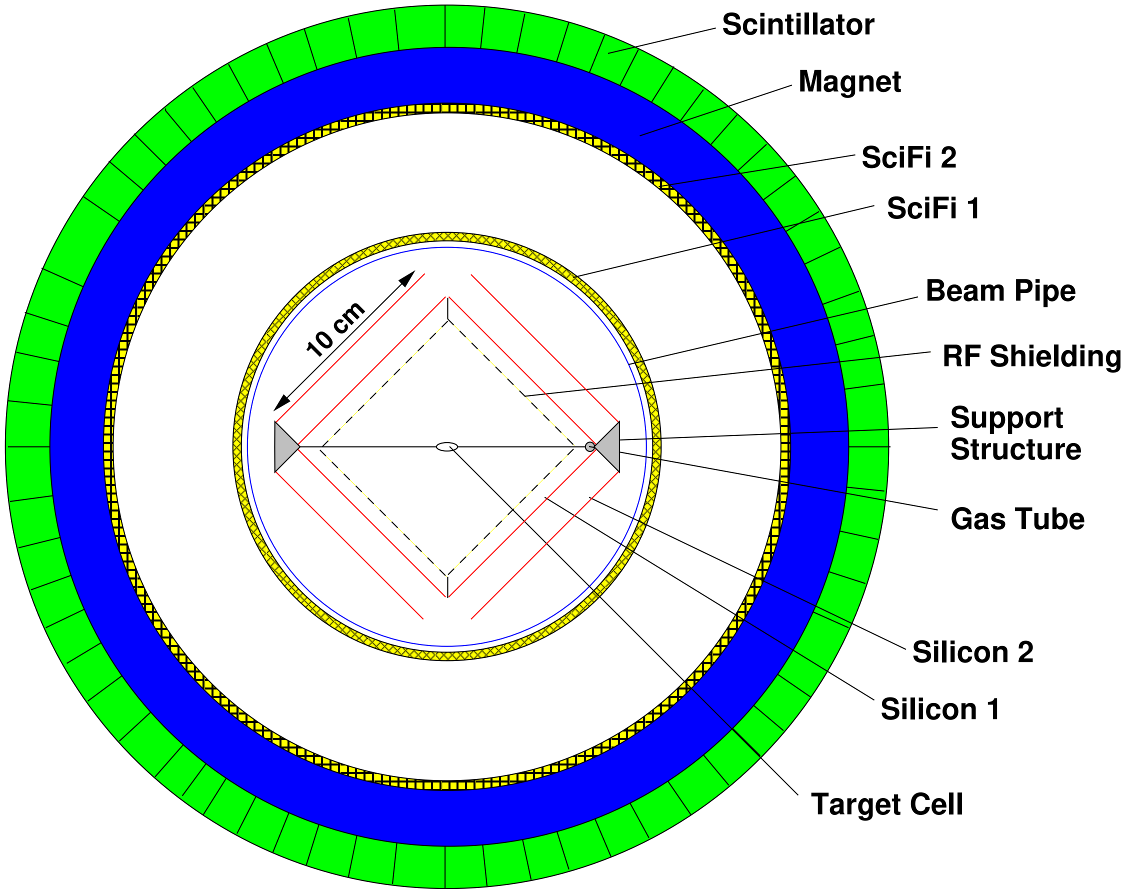
Exclusive limit $(z \rightarrow 1)$:

Effect nearly one order of magnitude higher, compared with SSAA on π^+ production in the lower z-range!
Indication for a different mechanism.

Missing-mass resolution of the HERMES spectrometer not sufficient to be fully-exclusive!

$\rightarrow$ Recoil Detector

Conceptual Detector Design



Si-tracker
recoil proton tracking (lower momenta) p momentum from dE/dx π/p PID from dE/dx

SciFi
recoil proton tracking (higher momenta) charged pion tracking p momentum from deflection π/p PID from dE/dx

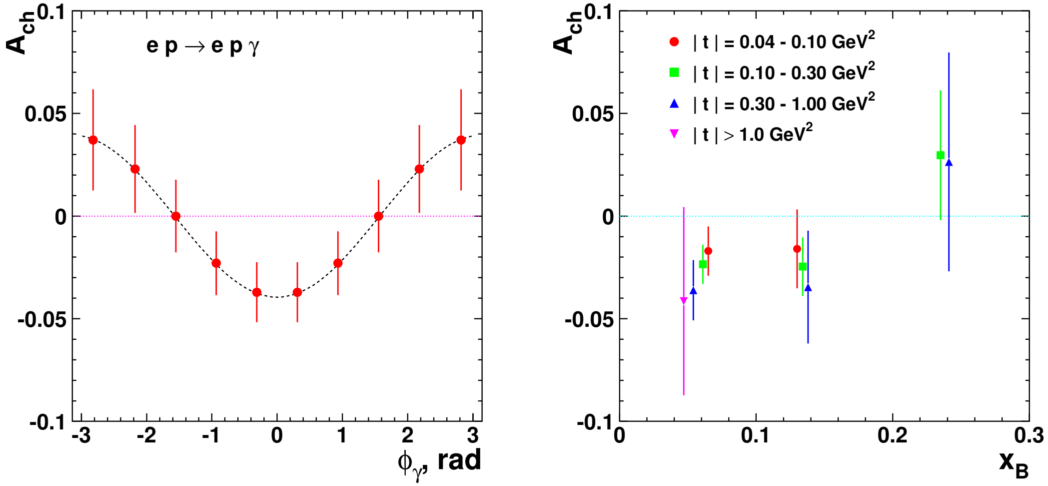
Magnet
proton momentum with SciFi Møller background reduction

γ-detector
neutral pion detection

R.Kaiser

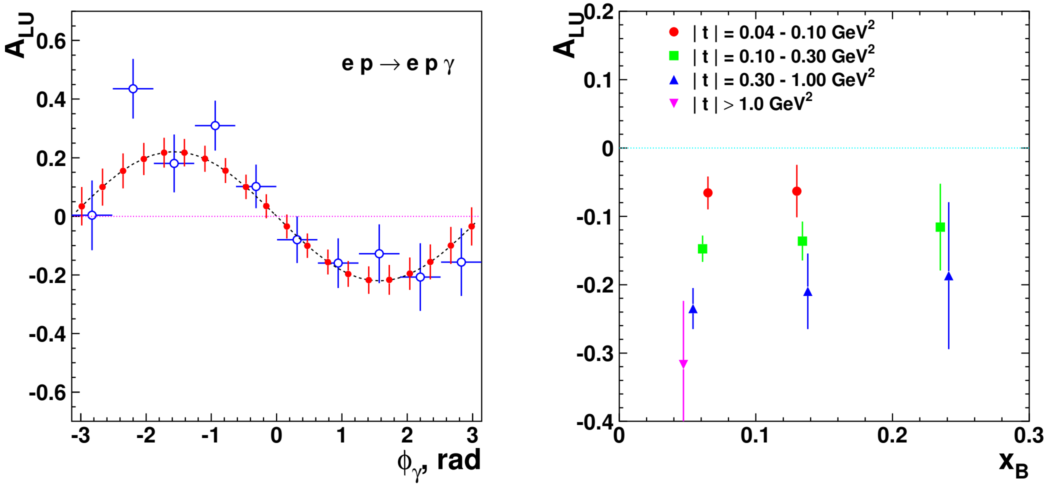
Projections for DVCS Measurements with a Recoil Detector

Lepton Charge Asymmetry



[V..Korotkov, W.-D.Nowak, in preparation]

Lepton Helicity Asymmetry



Projections based on 2 fb^{-1}, simple SPD ansatz.

$\Rightarrow$ Unique Ability of HERMES !

R.Kaiser

Status of the Detector I: Shutdown Work

hermes

- No major upgrade except on target long. $\vec{D} \rightarrow$ transv. $\vec{H}$
- Maintenance of magnet chambers (MC) and long. polarimeter (LPOL)
- Λ wheel test installation, installation of beam-loss monitors

final installation during
22.-24.Oct. access

part of trigger system for the
electron beam dump

- Detector back in beam position, functionality tests in progress
- Target on schedule
  Commisioning will start in 2 weeks, when the transverse magnet
  and target chamber have been installed (polarization tuning, cooling tests etc)

HERMES will be ready for closing the exp. area in early July!

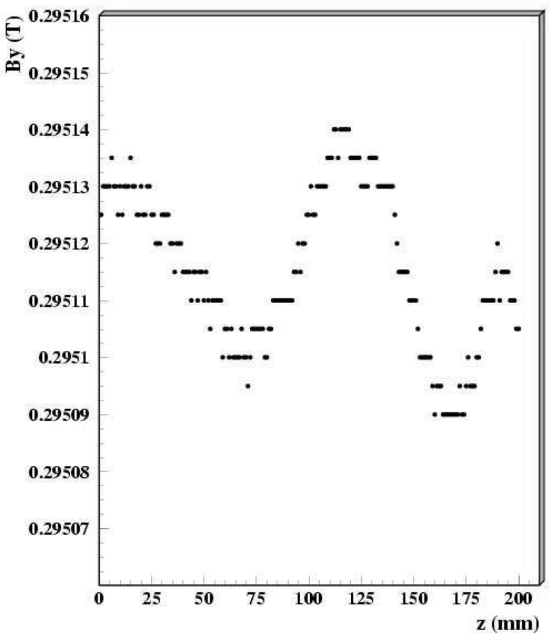
Status of the Detector II: Transverse Target Magnet

Challenge: • Good-field region inside target cell (400mm long): $B_o = 0.3T$, $\Delta B < 0.1mT$ $3x10^{-4}$
• Large gap in comparison with available lateral and longitudinal space.

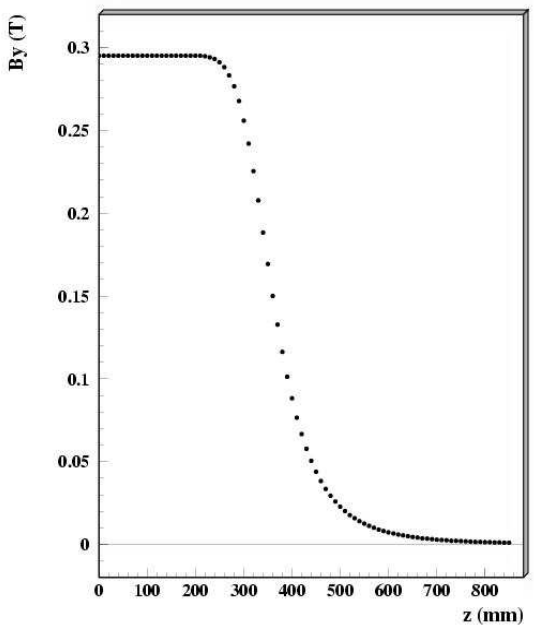
→ 3D field calculations at MPY-DESY and INFN-Roma; solution found which employs high-flux material for the pole shoes. Magnet constructed and measured at DESY.

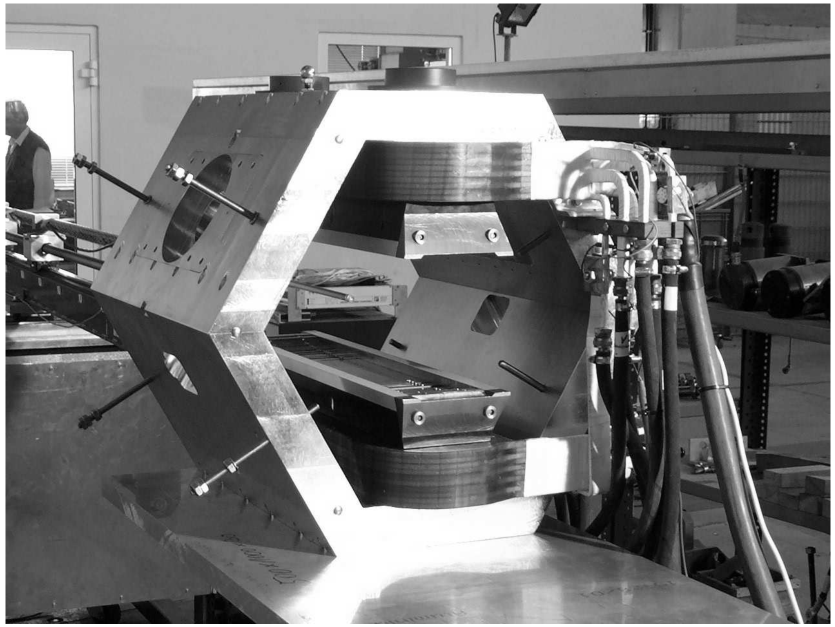
Results:

Field $B_y(z)$ at x = y = 0 (on axis) after ~ final shimming (zero suppr.)



Field distribution on axis without zero-suppression





Transverse magnet on the test bench at DESY in Hall 2

Conclusions

- Strong effort on analysis has led to numerous new results:

Δq_f, $A_{UL}{}^{\pi}$, $A_{LU}{}^{\gamma}$ (DVCS) , hadron multiplicities and mult. ratios, high-p_T hadrons, VMs . . .

- The Collaboration is preparing for a 3-years run (2001 – 2003) with transverse target, plus high-density end-of-fill runs.

- Proposal to build a large-acceptance recoil detector combined with high-density unpolarized targets: → study of exclusive, beam-spin related quantities like DVCS or π-SSAA <u>with high statistics!</u>

Challenge: ready for installation during 2003/04 shutdown.

→ Exciting physics programm for Run-II !