# Status report of Hermes

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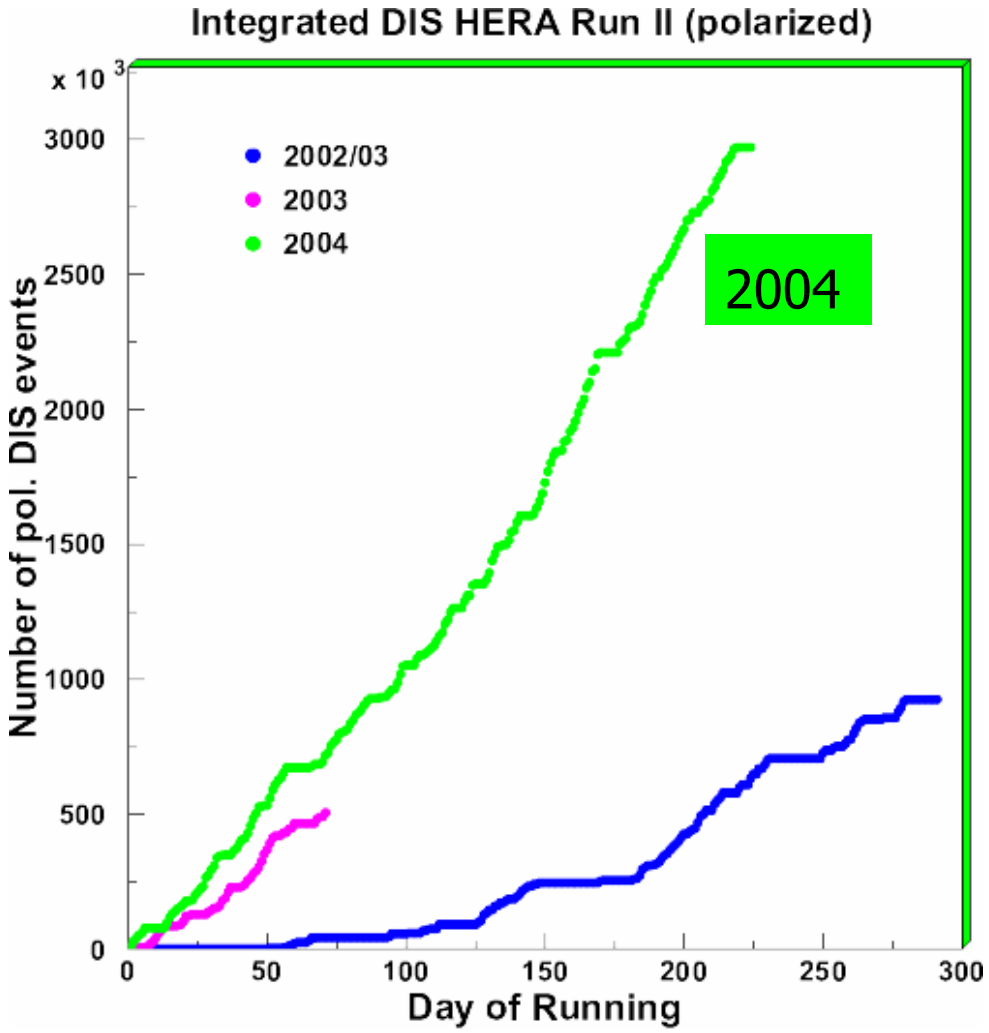
Physics Research Committee, DESY Oct 27/28 2004

- Spin physics:

  → finalised and new results on:
  inclusive, semi-inclusive and exclusive measurements

- nuclear effects

# data taking 2004




- very successful data taking with *transversely* polarised H target

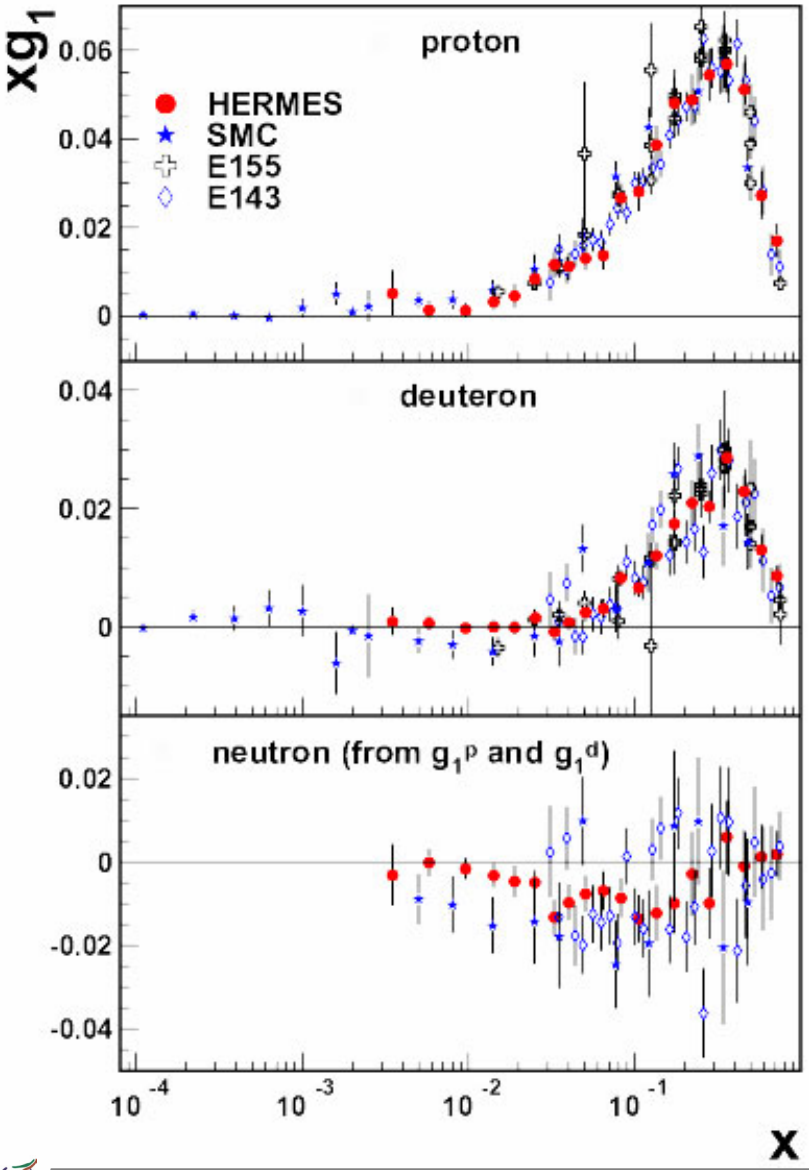
→ *transversity and friends*
(see PRC56,57 reports)

- high statistic data sets on unpolarised D, Kr, Xe from end-of-fill runs

→ nuclear effects

→ exclusive processes

# polarised structure function $g_1(x)$




→ *final* data set on $g_1(x)$

→ reanalised $g_1^p$

→ finalised $g_1^d$

- new, more rigorous bin to bin unfolding procedure applied:

→ accounts for radiative+acceptance

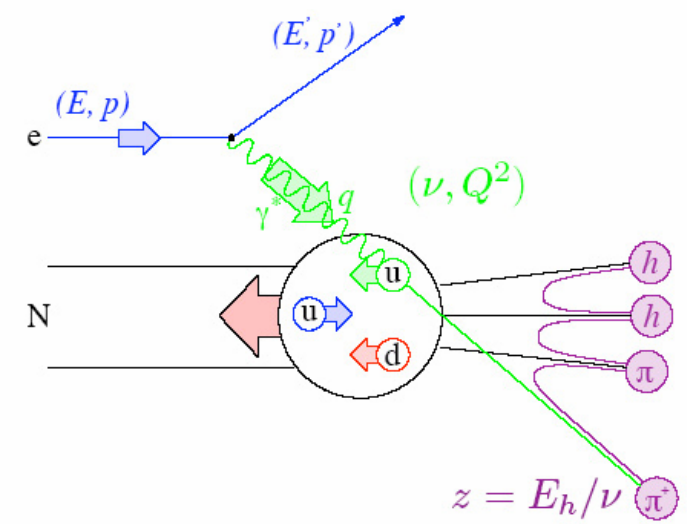
→ *uncorrelates systematic uncertainties*

→ (small) *statistical correlation known*

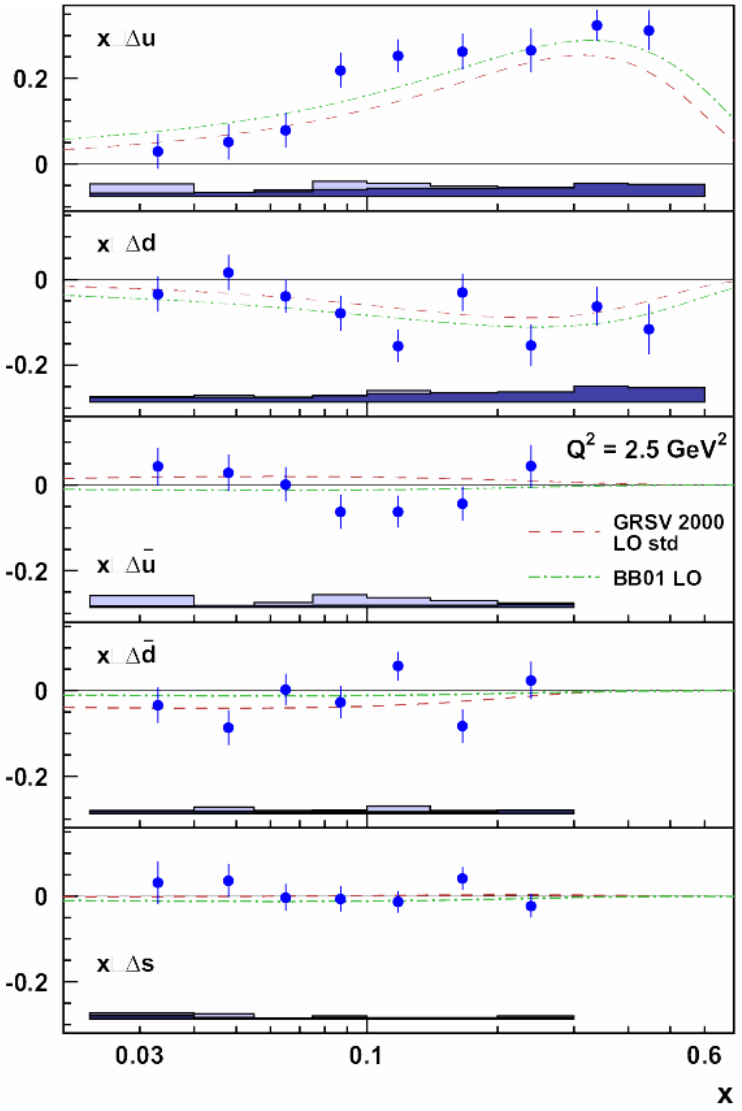
<u>world data:</u> $Q^2 < 100\ GeV^2$

$0.002 < x < 0.9$ for $Q^2 > 1\ GeV^2$

# quark polarisations from sidis




*first 5-flavour fit* to Δq




→ flavour separation by flavour tagging

$$A_1^h(x) \approx \frac{\sum_q e_q^2 \, \Delta q\,(x) \int dz\, D_q^h(z)}{\sum_q e_q^2 \, q\,(x) \int dz\, D_q^h(z)}$$

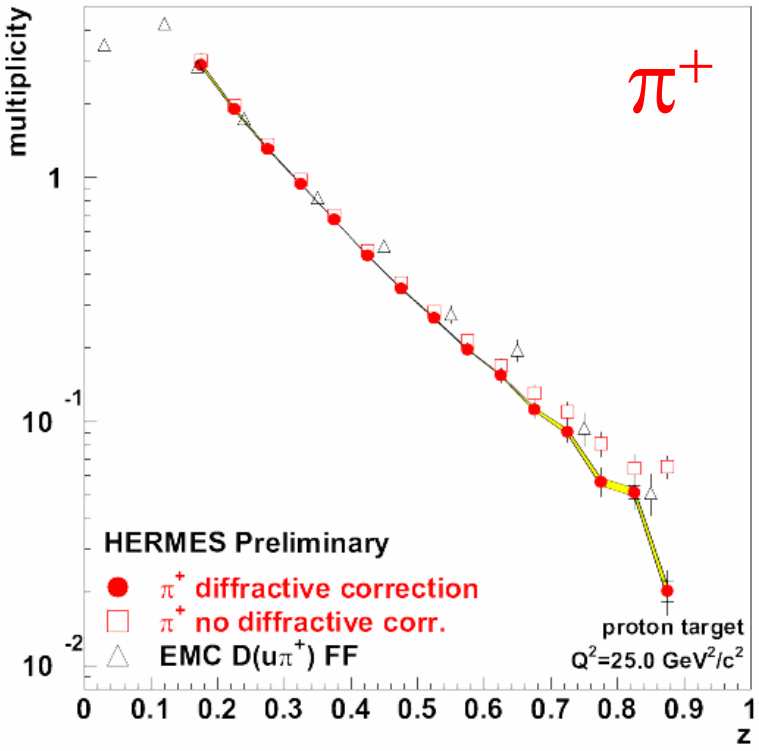
*Purities*

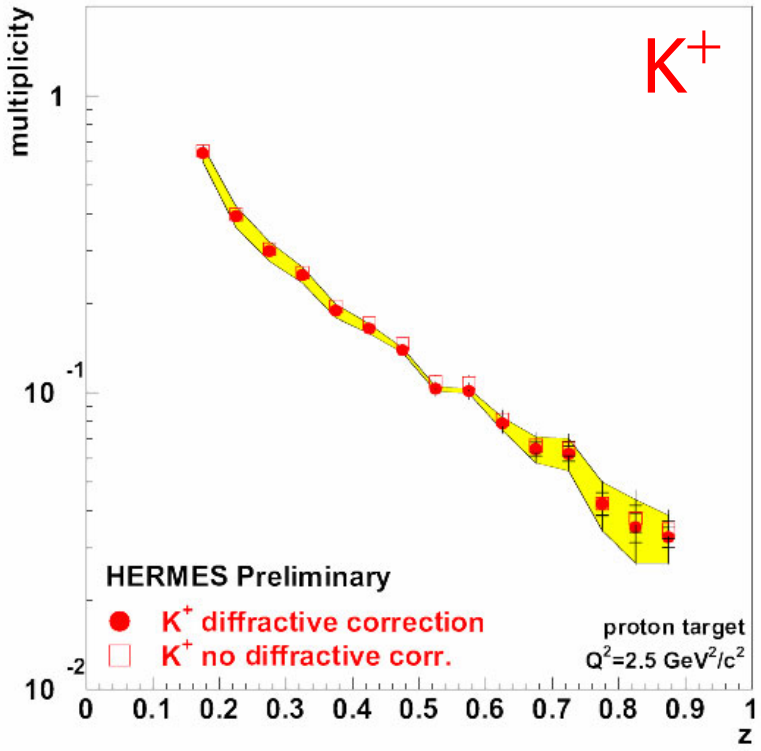
unpolarised pdfs and *fragmentation funtions*

# outlook: *FF* from multiplicities

→from high statistic polarised and unpolarised proton data set:

$\pi^+$ ,$\pi^-$ , $K^+$, $K^-$ multiplicities

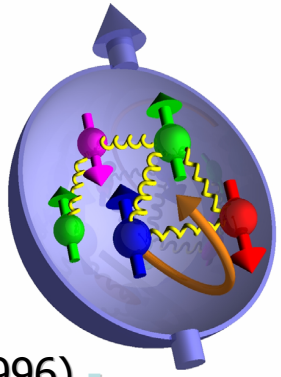



→extraction of $\Delta q$ with Hermes set of *fragmentation functions*

→towards NLO analysis of $\Delta q$

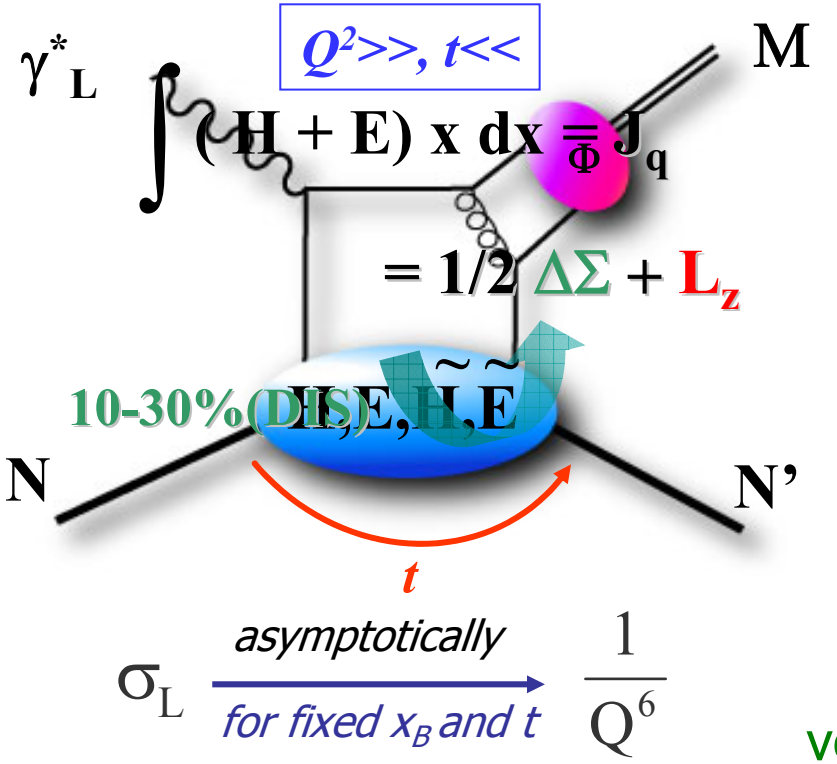
# hunting for $L_q$



factorisation theorem for *hard exclusive processes:*
**G**eneralised **P**arton **D**istributions

- Műller (1994) -
- Ji & Radyushkin (1996) -

meson production:




$$\sigma_L \xrightarrow[\text{for fixed } x_B \text{ and } t]{\text{asymptotically}} \frac{1}{Q^6}$$

4 GPDs @twist-2:

| | | |
|---|---|---|
| H | $\tilde{H}$ | conserve ~ |
| E | $\tilde{E}$ | flip nucleon helicity |

quantum number of final state selects different GPDs:

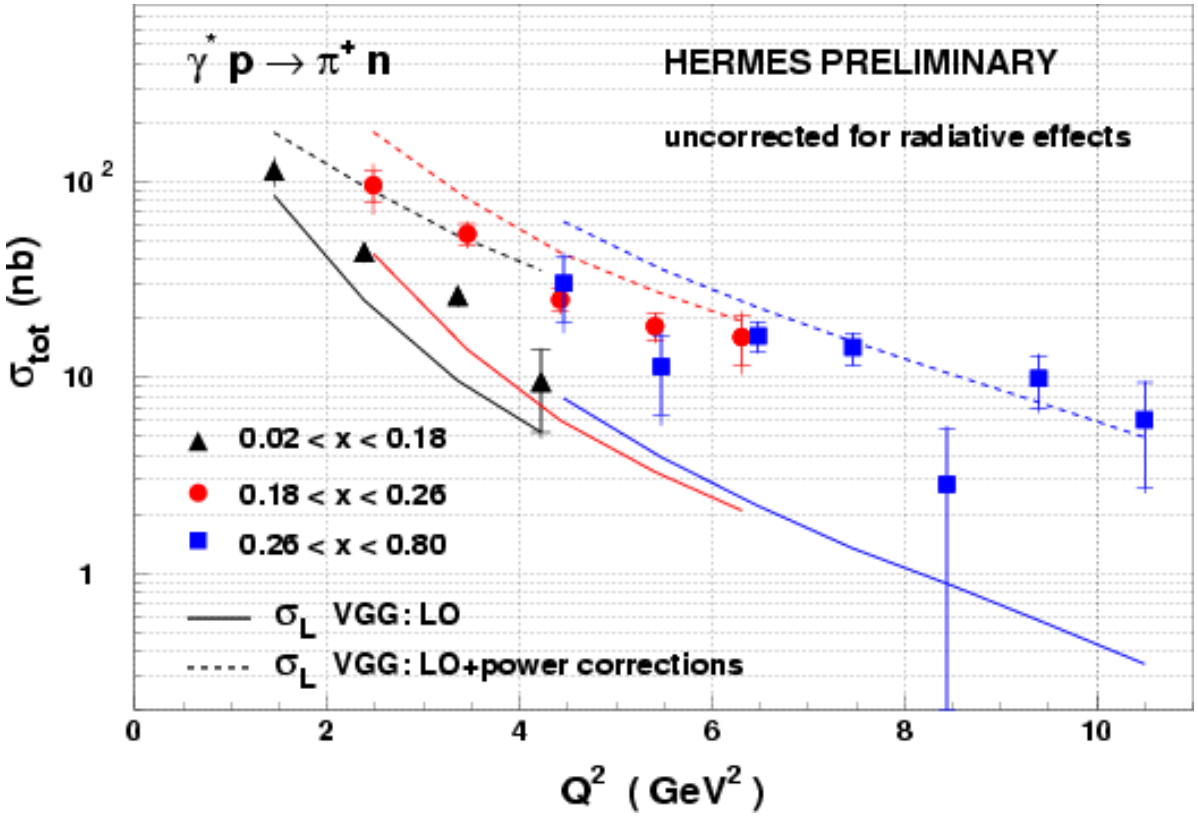
→ DVCS ←

⇩ vector mesons

⇩ pseudoscalar mesons

# cross section for ep → e′π⁺n

comparison with GPD based model: *-Vanderhaeghen, Guichon & Guidal (1999) -*
exclusivity ensured by missing mass technique




$$\sigma_{tot} = \sigma_L + \varepsilon\,\sigma_T$$

L/T separation not possible

… but:

$\sigma_T$ suppressed by $1/Q^2$

Hermes kinematics:

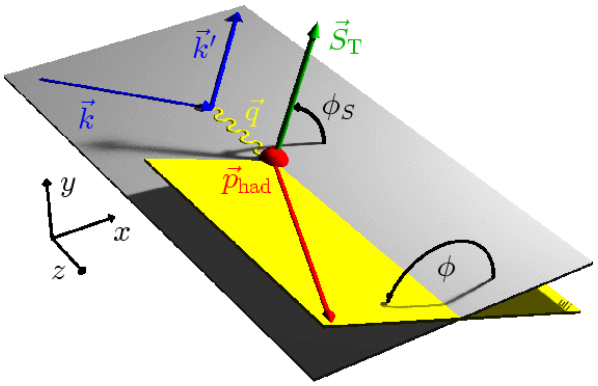
$0.80 < \varepsilon < 0.96$

→ at large $Q^2$ $\sigma_L$ dominates

→ Q2 dependence in general agreement with theoretical expectation

→ *power correction* ($k_\perp$ and soft overlap) calculation overestimate data

# outlook: transverse target-spin asymmetry

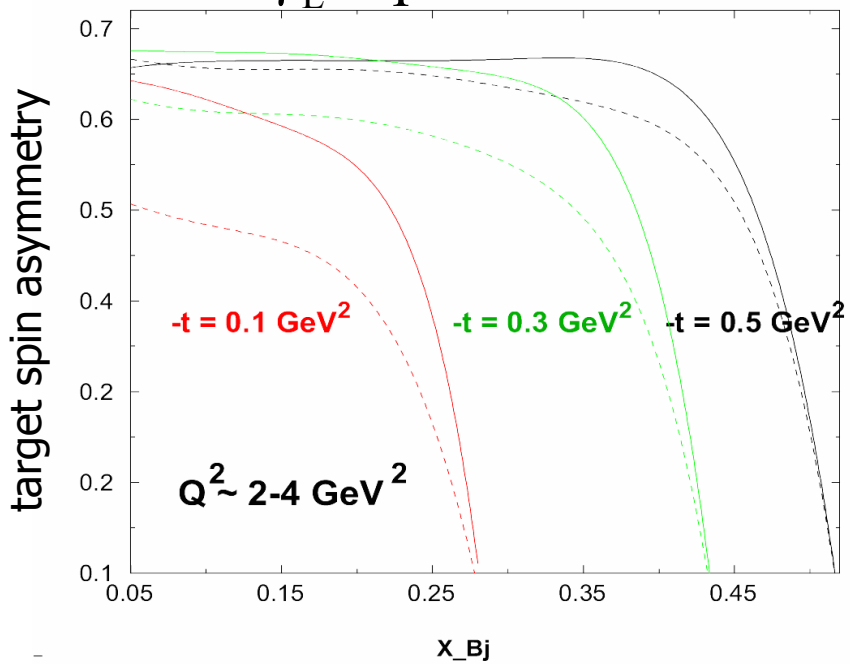



→ *quadratic* combination of GPDs appears in unpolarised cross section

→ TSA *linear* dependence on E and H, $\tilde{E}$ and $\tilde{H}$

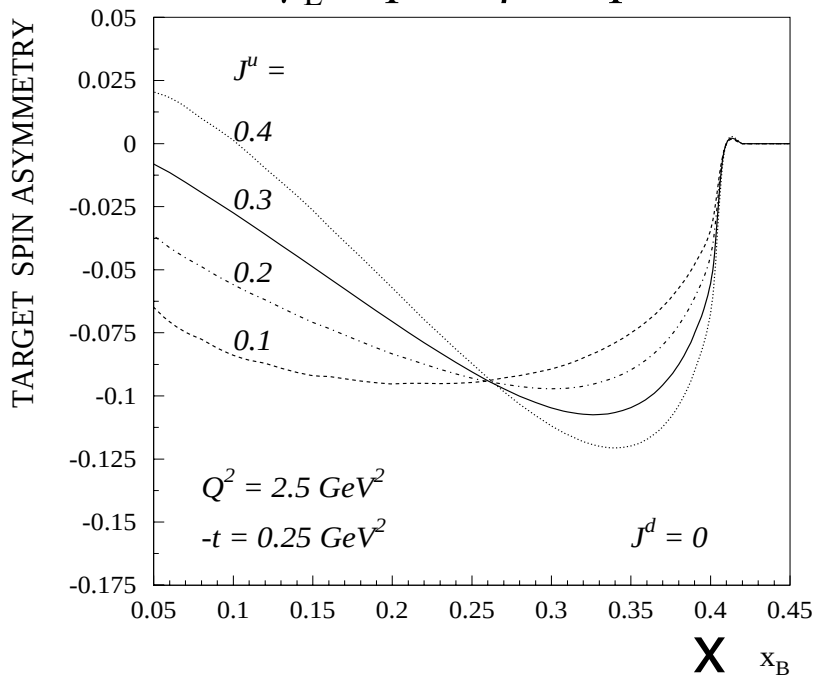
$$\sigma_s \propto |S_T| \sin(\phi - \phi_S)\, E \cdot H$$

$$\gamma_L^* + p \rightarrow \pi^+ + n$$




→pion pole contribution

$$\gamma_L^* + p \rightarrow \rho^0 + p$$




→particulary sensitive to *E*

PRC58

# exclusive $\pi^+\pi^-$ production

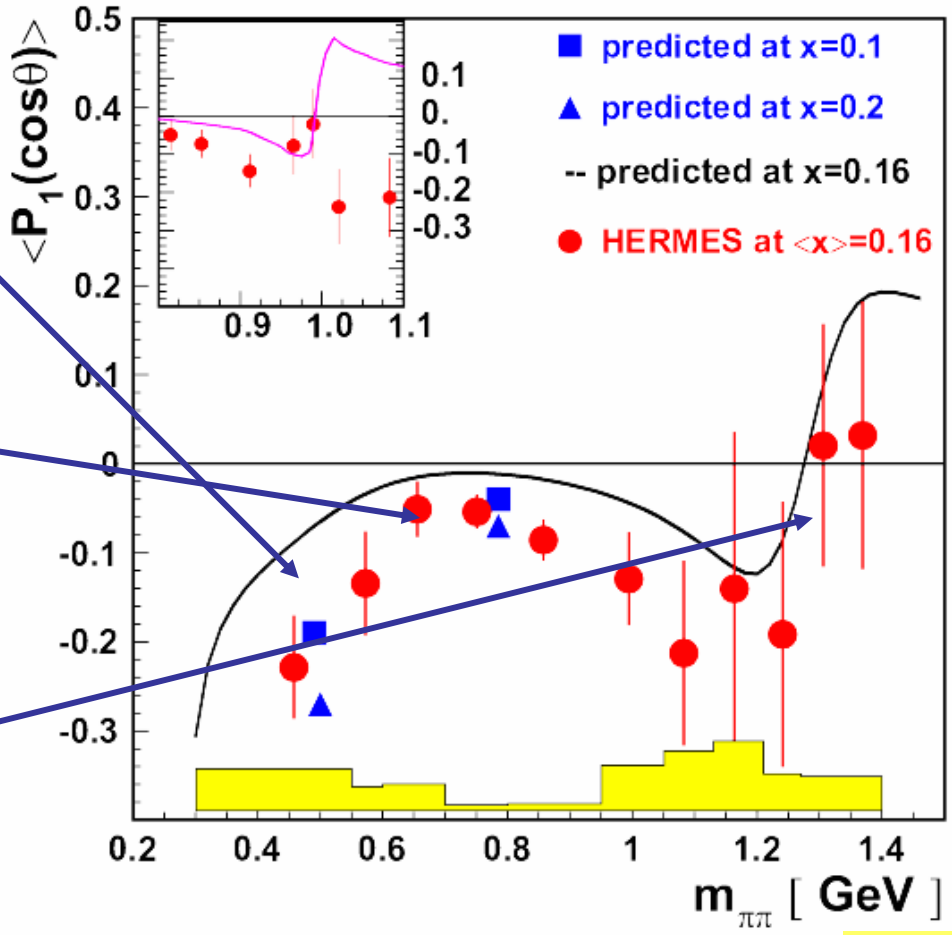
$$e\,p\,(d) \rightarrow e'\,p\,(d)\;\;\pi^+\pi^-$$

sensitive to interference between different $\pi^+\pi^-$ isospin states

interference between S-wave and lower $\rho^0$ tail
$m_{\pi\pi} \leq 0.6$ GeV

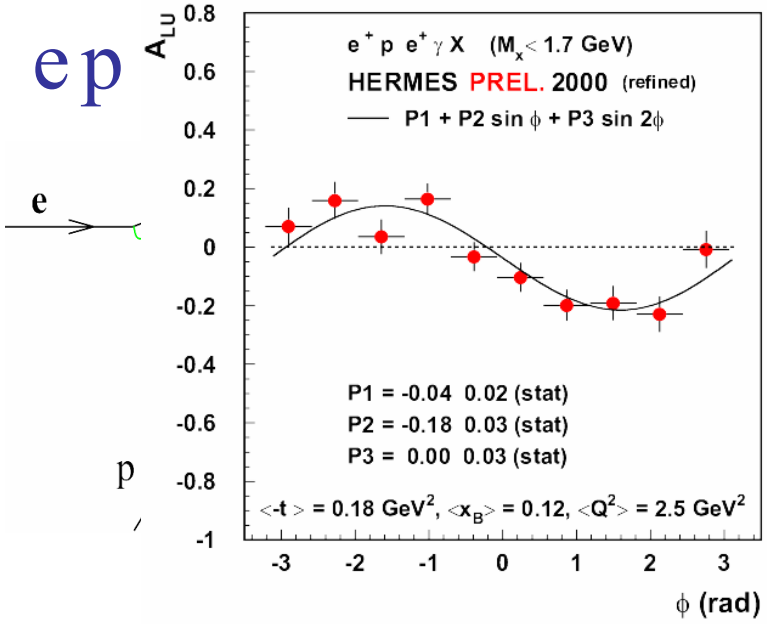
→GPD model predictions:
minimum interference between S-P waves
$m_{\pi\pi} \sim 0.77$ GeV
w/o 2-gluon exchange
with 2-gluon exchange

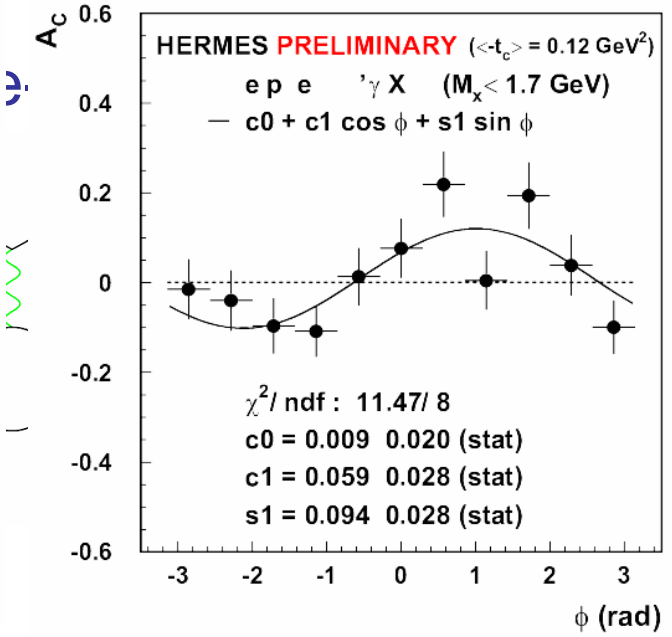
*@low x:* sensitive to 3-gluon exchange → *Odderon*
indication of $\rho^0 - f_2$ interference
$m_{\pi\pi} \sim 1.3$ GeV



# Deeply Virtual Compton Scattering

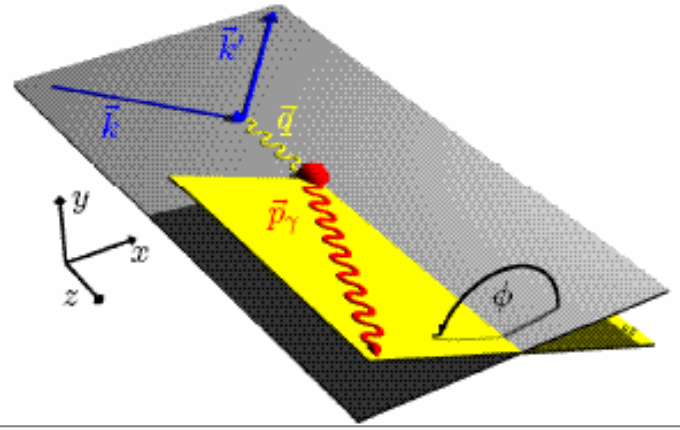
e p




natics:
-Heitler

$$d\sigma \propto |\tau_{BH}|^2 + |\tau_{DVCS}|^2 + (\tau^*_{BH}\tau_{DVCS} + \tau^*_{DVCS}\tau_{BH})$$

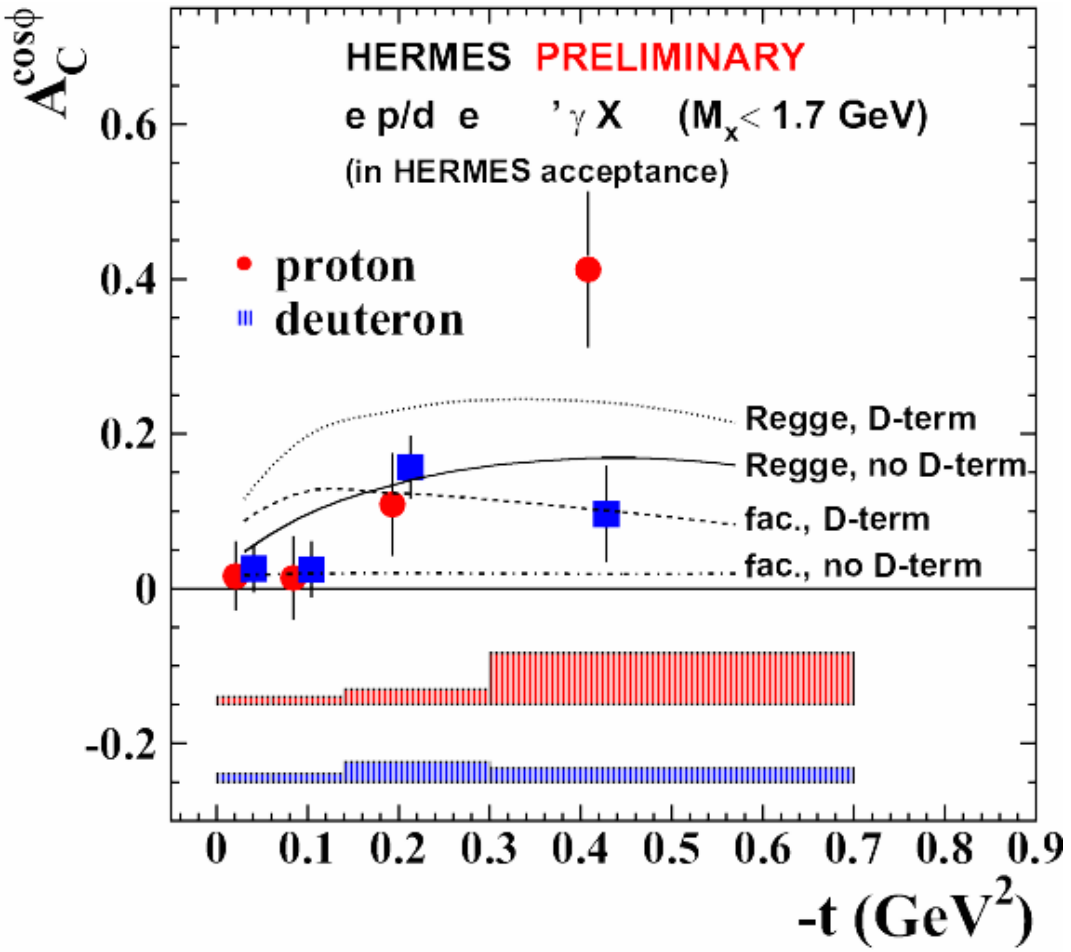



DVCS-BH interference leads to non-zero azimuthal asymmetry

$$A_{LU}^{\overleftarrow{\Rightarrow}}(\phi) \propto \mathrm{Im}\,(\tau_{BH}\,\tau_{DVCS})$$

$$A_C^{+/-}(\phi) \propto \mathrm{Re}\ (\tau_{BH}\,\tau_{DVCS})$$

# latest news: BCA vs *t*




GPD calculations:

- Vanderhaeghen et al., (1999,2001) -

→ t-dependence of BCA: high sensitivity to model assumptions

different parametrisations for H:

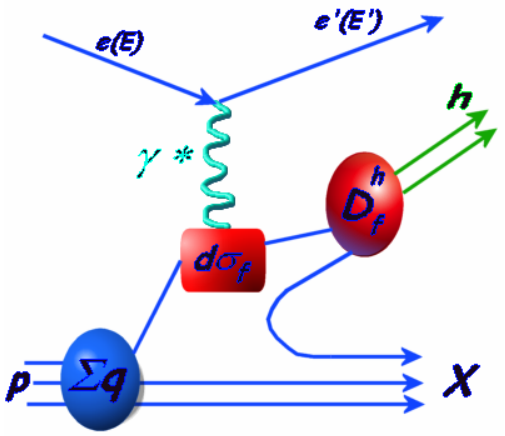
- t-dependence factorised
- Regge-motivated ansatz

with and w/o D-term

tiny $e^-p$ sample ($L \sim 10 pb^{-1}$)

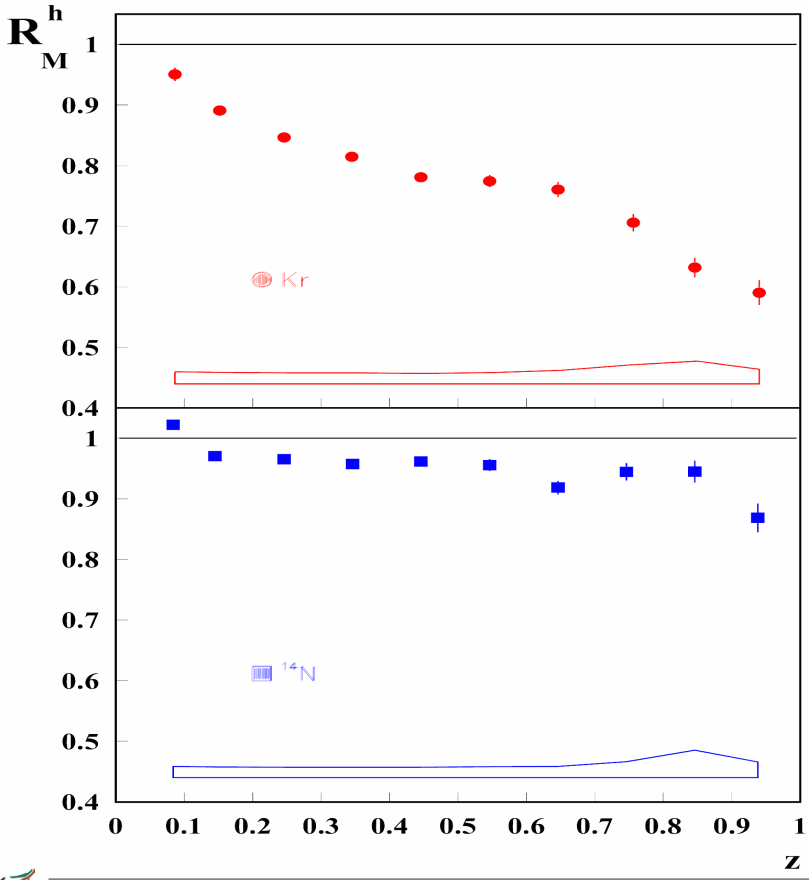
...BUT...

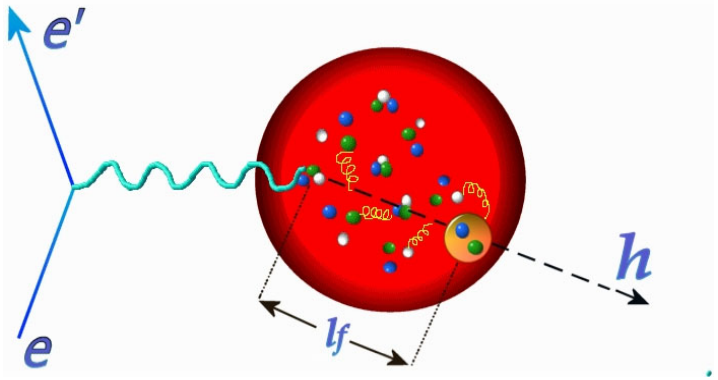
HERA: >2004 $e^-$




# what happens in a nuclear medium?

→ reduction of multiplicity of fast hadrons due to both *hard partonic* and *soft hadron interaction*

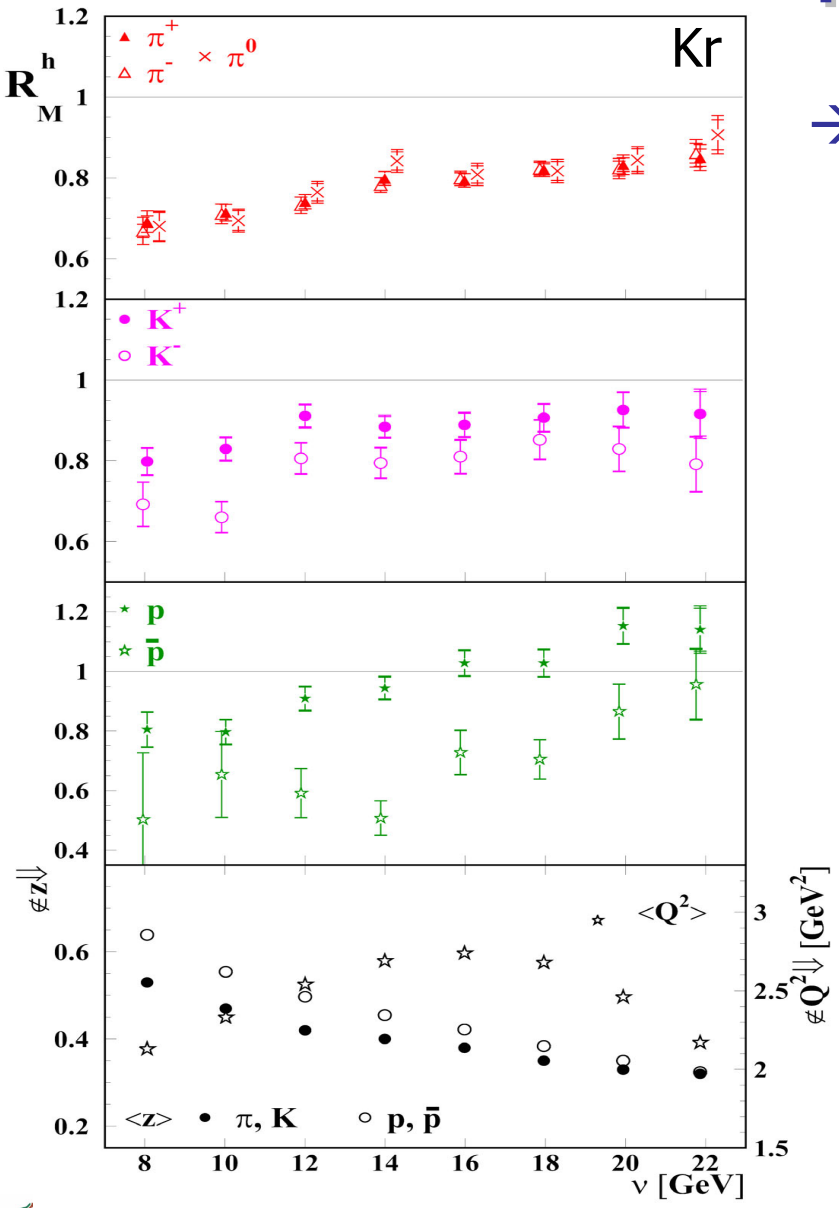



→ understanding of the space-time evolution of the hadron formation process

→ *FF* modification

# hadron separation vs ν




→ first time hadron discrimination in $\gamma^*N$

$\pi^+ = \pi^- = \pi^0 \sim K^-$ , $K^+ > K^-$

$p > \bar{p}$, $p > \pi$, $p > K$

→ Hermes energy well suited for study of nuclear effects

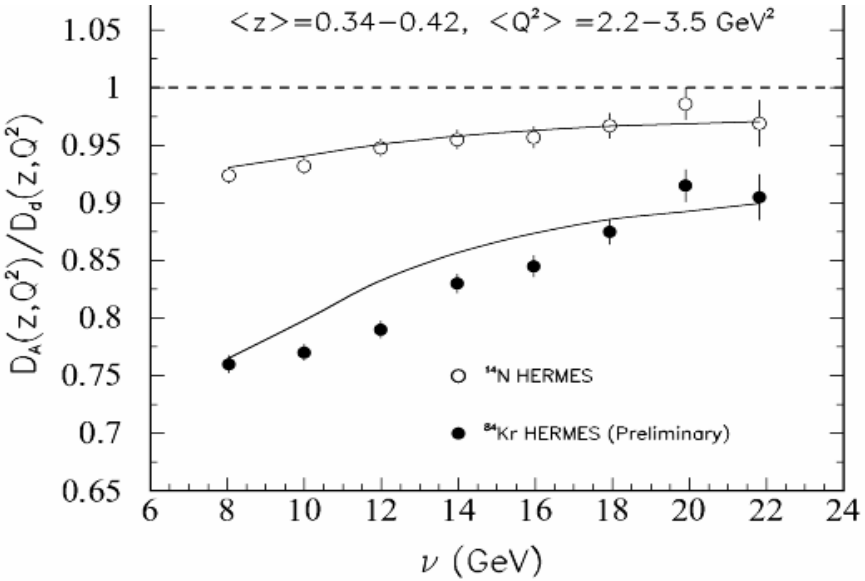
→ statistics on Kr doubled

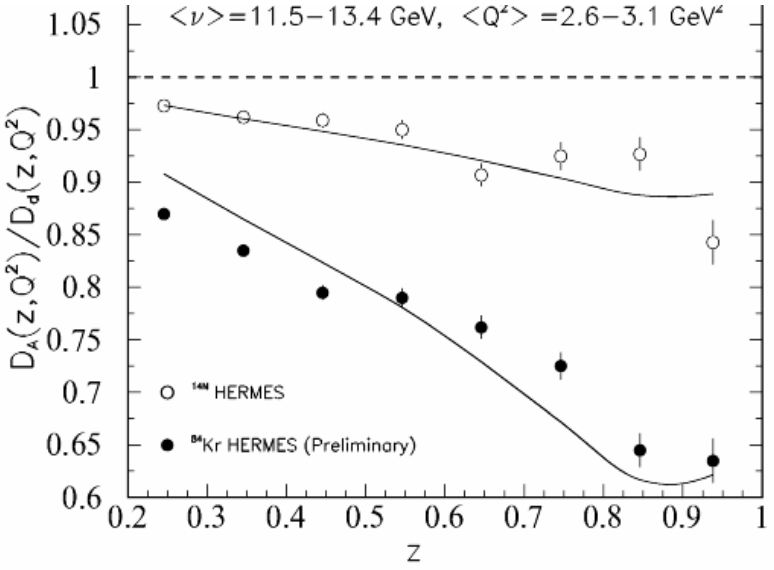
→ first data on Xe !

He, N, Ne, Kr, Xe → study A-dependence

# FF modification
## (parton energy loss)

[X.N.Wang et al., PRL89(2002)]



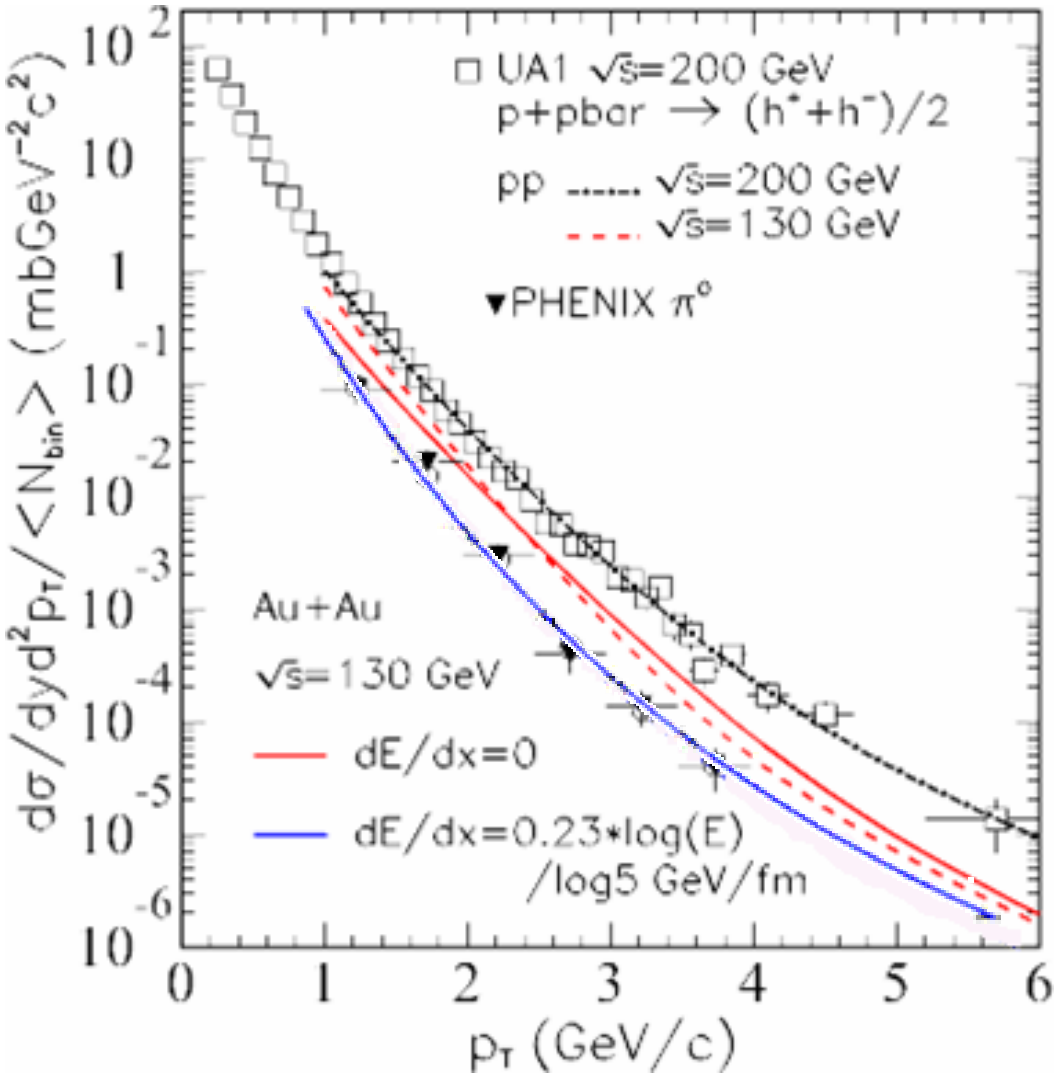




- 1 free parameter tuned on $^{14}N$ (quark-gluon correlation strength inside nuclei)

- dE/dx from HERMES → dE/dx for (Au+Au) @RHIC

# Gluon density

[X.N.Wang et al., PRL89(2002)]




cold ⟺ hot nuclear matter correlation

→ gluon density in Au+Au order of magnitude higher than in cold matter

fixed by HERMES data

# *new tool:* double-hadron attenuation

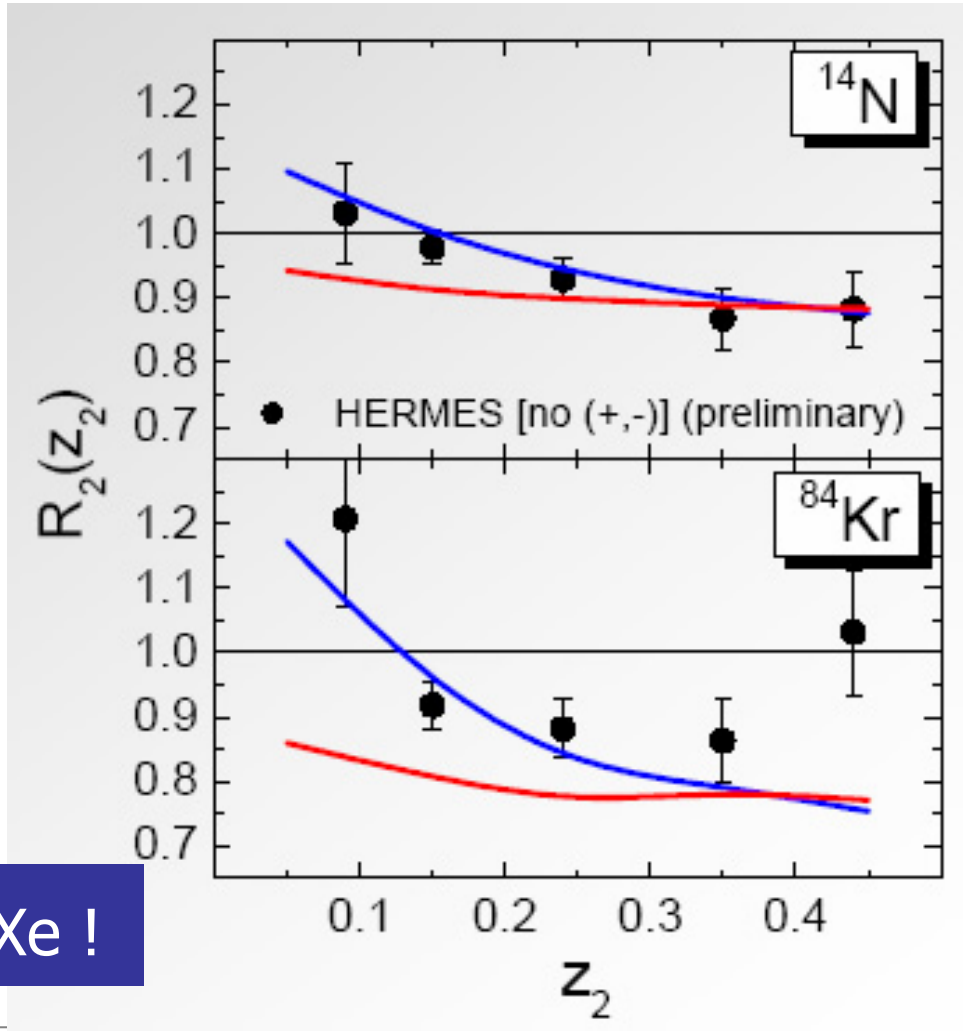
→ disentangling between absorption and energy loss

[T. Falter et al. 2004]

leading hadron: $z_1 > 0.5$

subleading hadron: $z_2 < z_1$

$$R_{2h}(z_2) = \frac{\left(\frac{N_2(z_2)}{N_1}\right)_A}{\left(\frac{N_2(z_2)}{N_1}\right)_D}$$



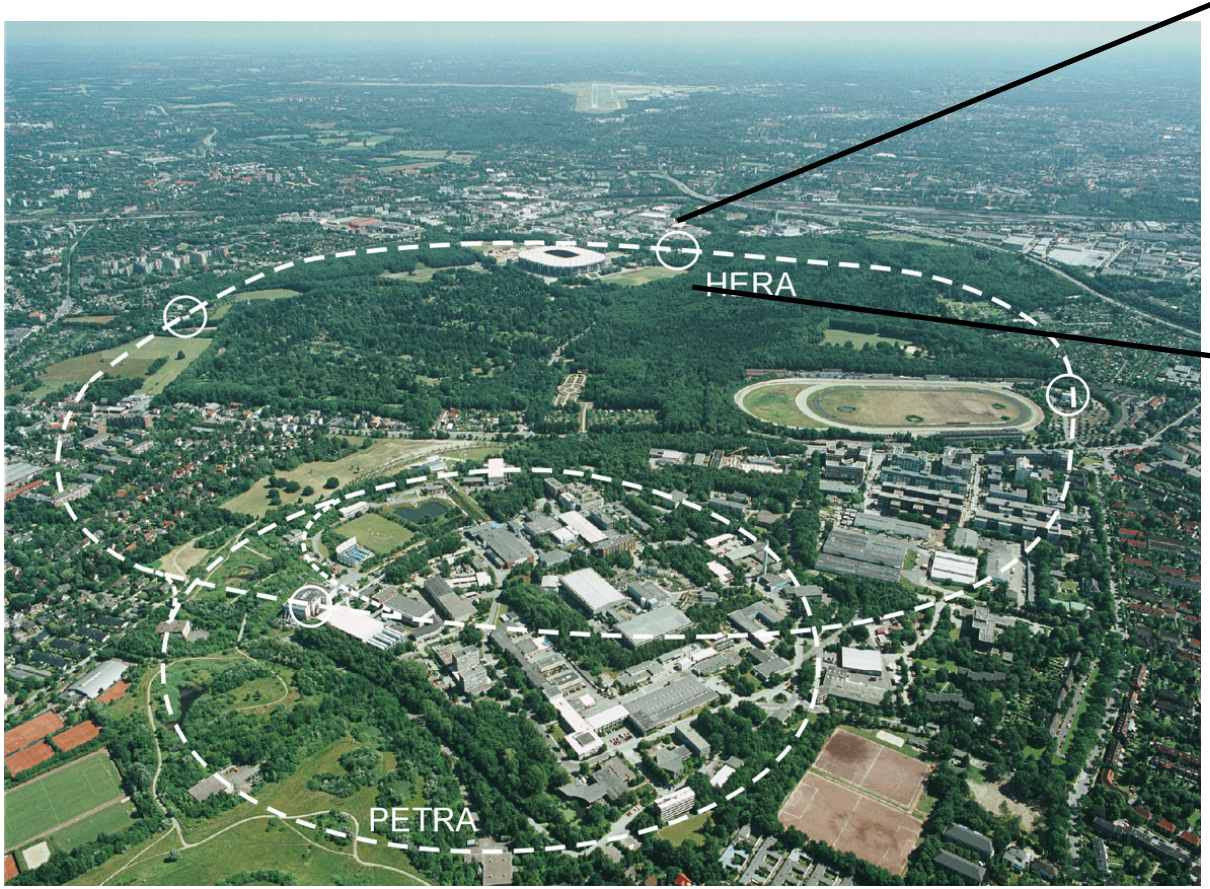

—— pure absorption model ruled out

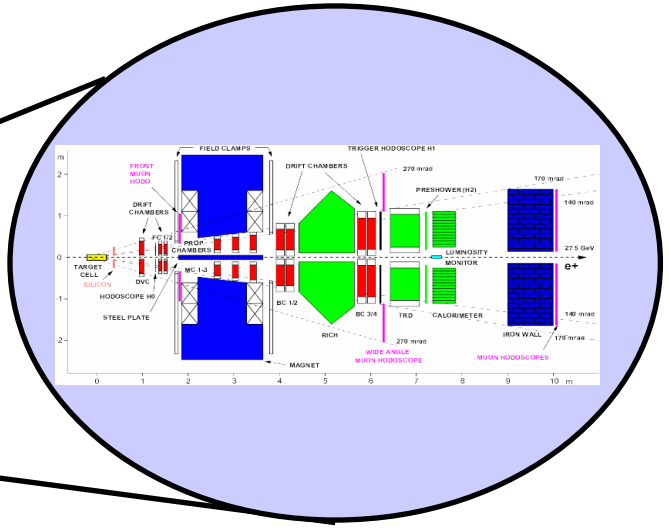
→ Kr statistics doubled; first Xe !

# outlook

*shutdown finished*

→ recoil on track



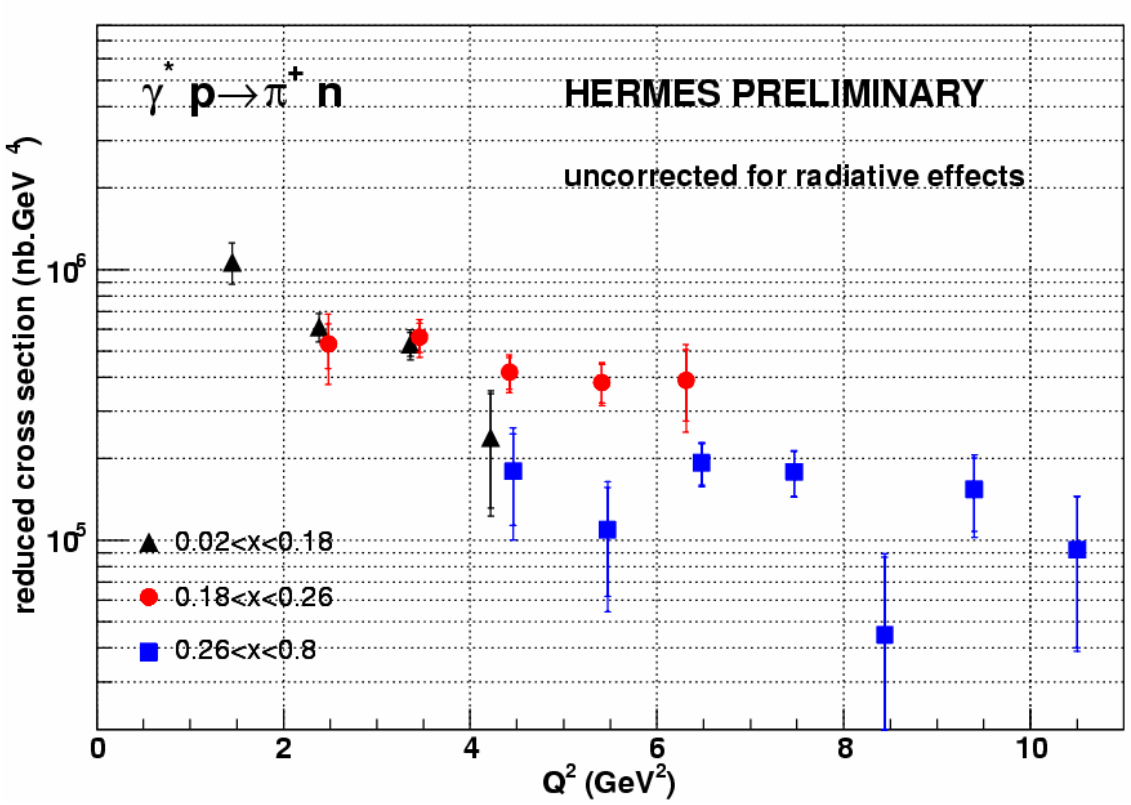

...E-Hall...

ready for taking

DATA!

# $\pi^+$ cross section: $Q^2$ dependence

factorisation theorem: $\sigma_L \xrightarrow[\text{for fixed } x_B \text{ and } t]{\text{asymptotically}} \frac{1}{Q^6}$




$$\sigma_L = \text{kine.factor}(Q^2, x)\ \sigma_{red}$$

$$\sigma_L \to \frac{1}{Q^4}$$

$$\sigma_{red} = \sum_{spins} |M|^2 \to \frac{1}{Q^2}$$

fit: $1/Q^p$

p=1.9±0.5

p=1.7±0.6

p=1.5±1.0

→ $Q^2$ dependence in agreement with theoretical expectation

# Power correction

*-Vanderhaeghen, Guichon & Guidal (1999) -*

→ intrinsic transverse momentum of the active quark ($k_{perp}$)

(Q2>>) → 0

→ soft overlap contribution → no gluon exchange