Structure of the proton

- **In QCD**

  quark (u, d, s ...) **and gluon fields**
  α_s **increases when** $Q^2 \to 0$

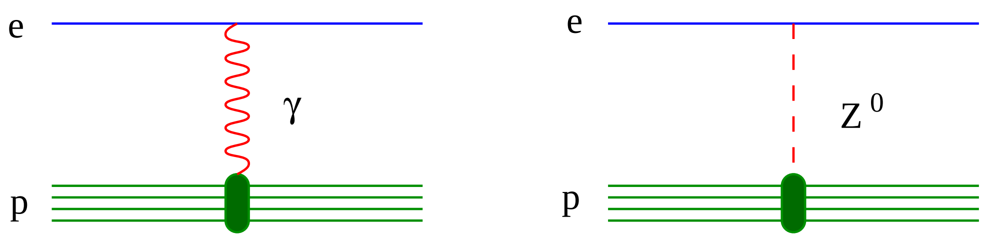
- **In the constituants quarks model**

  Elementary bricks : U, D, S ...
  Weakly interacting
  Describe static properties of hadrons

  "Q's are q's surrounded with
  $q\bar{q}$ **pairs and gluons"**

  $\Rightarrow$ **Look for strangeness !**
  Proton $= UUD$
  $m_s \sim \Lambda_{\mathrm{QCD}}$

Parity Violation in $\vec{e}$ P scattering



- **With polarized electrons**

$$\mathcal{A}_{PV} = \frac{\sigma^{\Rightarrow} - \sigma^{\Leftarrow}}{\sigma^{\Rightarrow} + \sigma^{\Leftarrow}} \simeq \frac{\mathcal{M}_\gamma \mathcal{M}^*_{Z^0}}{\mathcal{M}^2_\gamma} \simeq \frac{G_F Q^2}{\alpha_{QED}}$$

- **Depends on strange form factors**

$$\mathcal{A}_{PV} \simeq \quad -3.2\,10^{-4}\tau[(1-4\sin^2\theta_W)$$

$$- \quad \frac{\epsilon G^p_E(G^n_E + G^s_E) + \tau G^p_M(G^n_M + G^s_M)}{\epsilon(G^p_E)^2 + \tau(G^p_M)^2}]$$

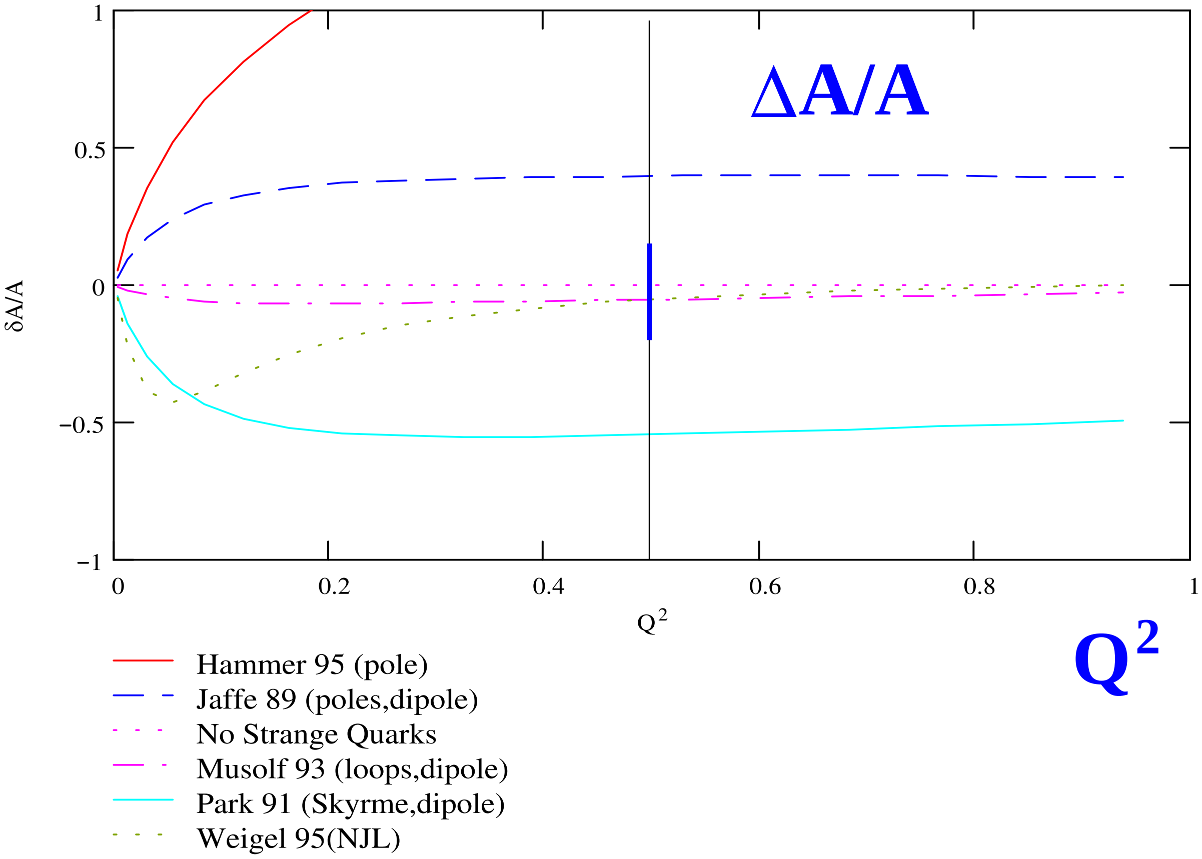
- **Kinematics**

$Q^2 =$ **0.5 (GeV/c)**^{2}, $\theta = 12.5°$

$\mathcal{A}_{PV}$ **= -15 ppm**

Sensitivity of the measurement

- Various models ...



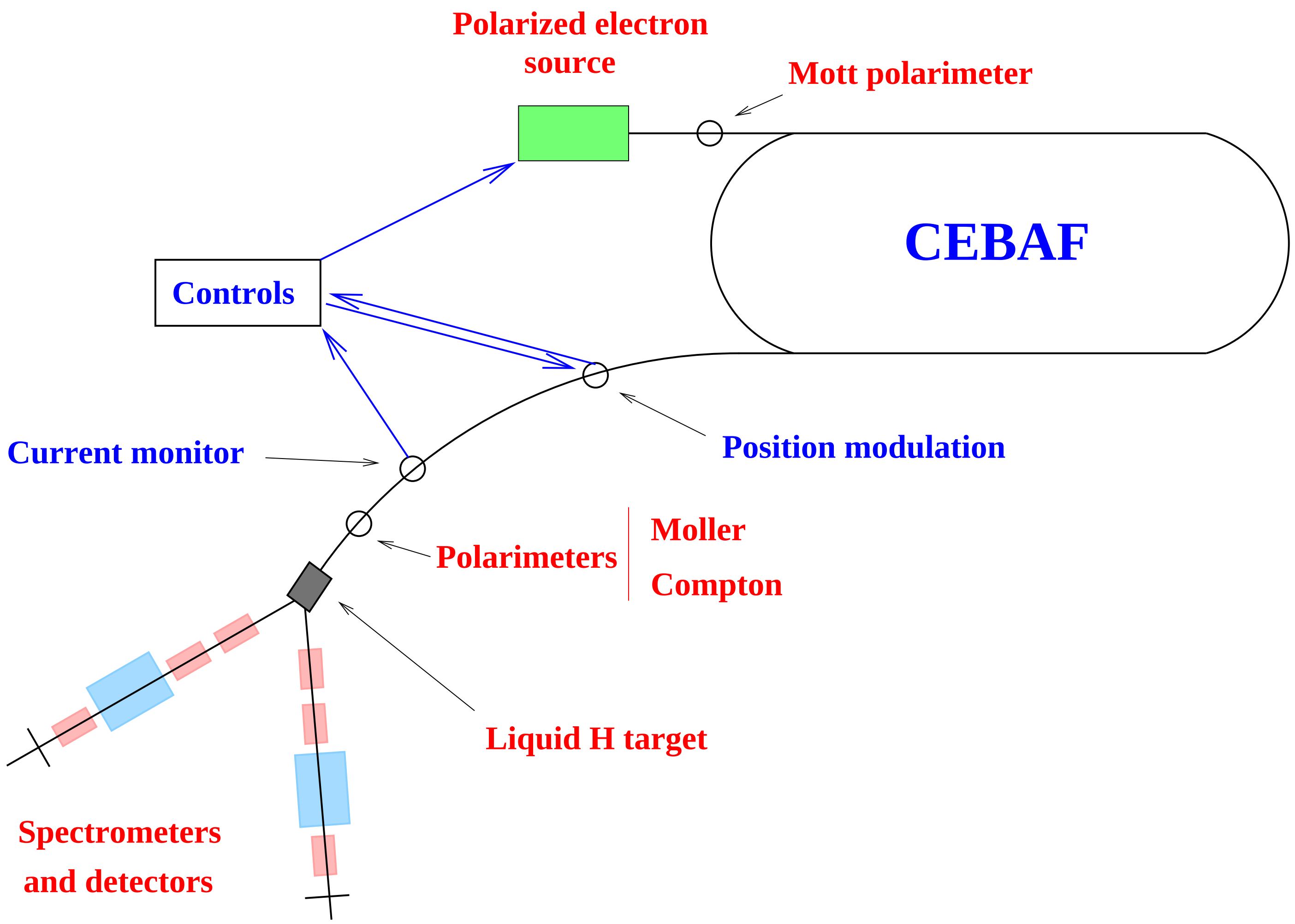
$\Rightarrow$ **Which degrees of freedom ?**

- This data : $\Delta A/A = 15\%$

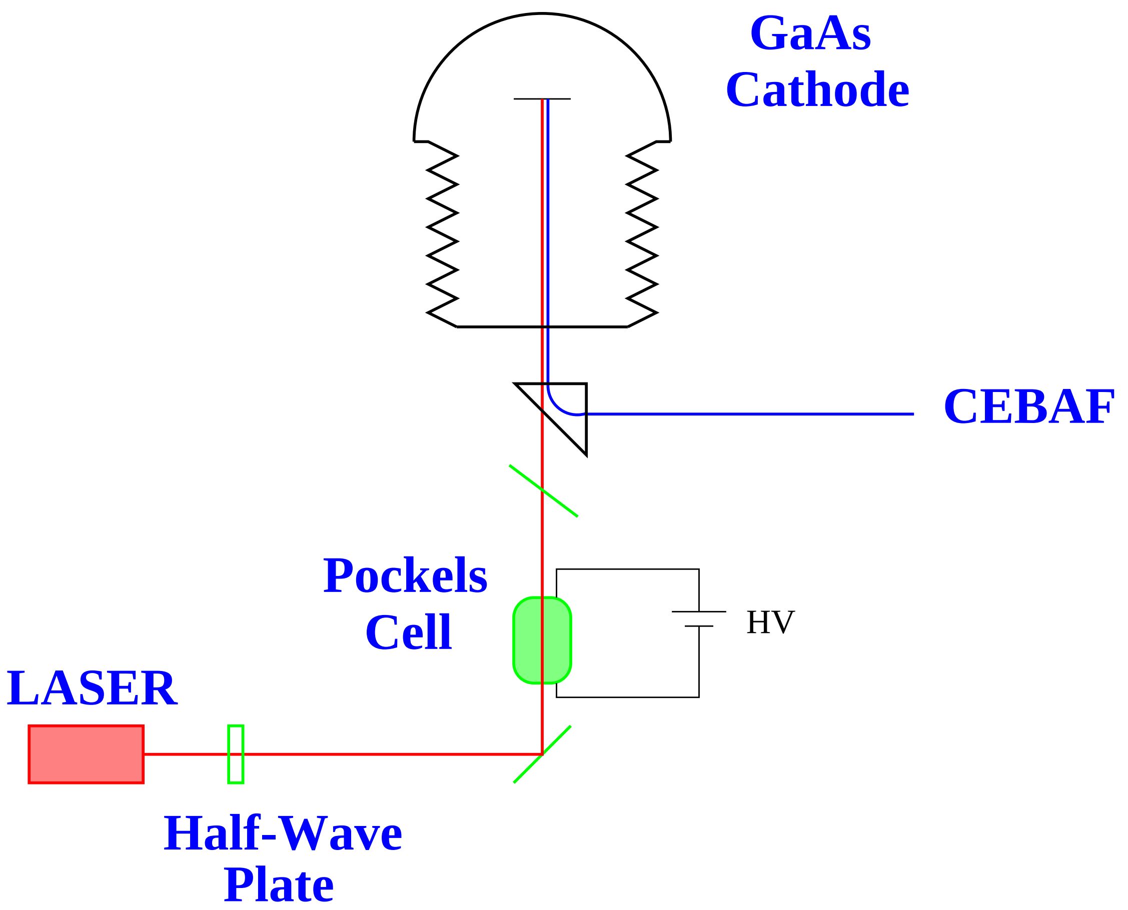
Overview of HAPPEX

Hall A Proton Parity EXperiment at Jefferson Lab, Virginia, USA.

E=3.355 GeV, $Q^2 = 0.5\ (\mathrm{GeV/c})^2$
Counting rate : 2 MHz
$\mathcal{A}_{\mathrm{exp}}$: 6 ppm



The polarized source



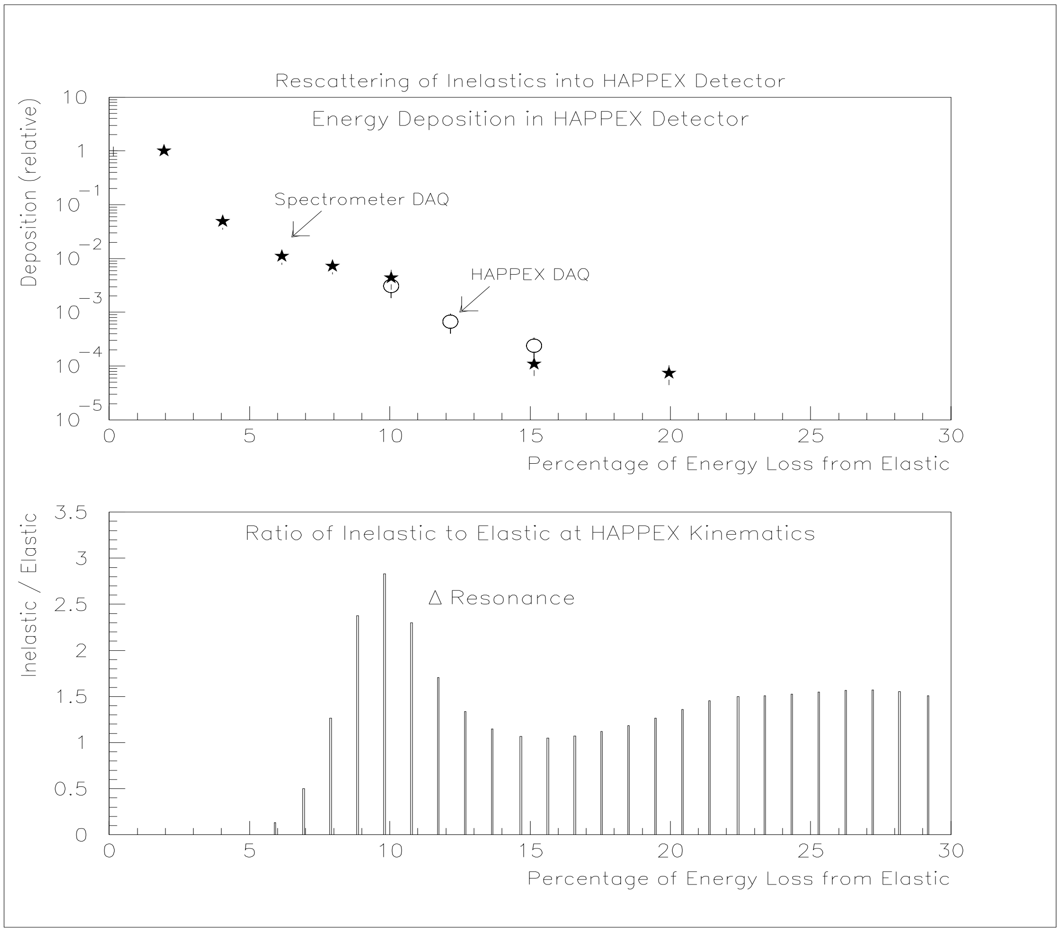
- P_e=40%, I=100 μA, 85 C on target.

- Helicity flipping
  Locked to 60 Hz
  First of a pair is pseudo-random

- Half-wave plate
  $\Rightarrow$ Reverse sign of $\mathcal{A}_{\text{exp}}$

Background

- Sources
  - Inelastic contamination
  - Quasi-elastic on target window
  - Scattering on magnetized iron
- Estimation of the effect



- Contribution : $\Delta A/A = 0.6 \pm 1.7\%$

Beam polarisation

- **Mott Polarimeter** (*See S. Prices's talk*)

  Principal errors :

Foil thickness	5 %
Background	3 %
Intensity dependence	3 %
Total	7 % ($\Rightarrow$ 3%)

- **Moller Polarimeter**

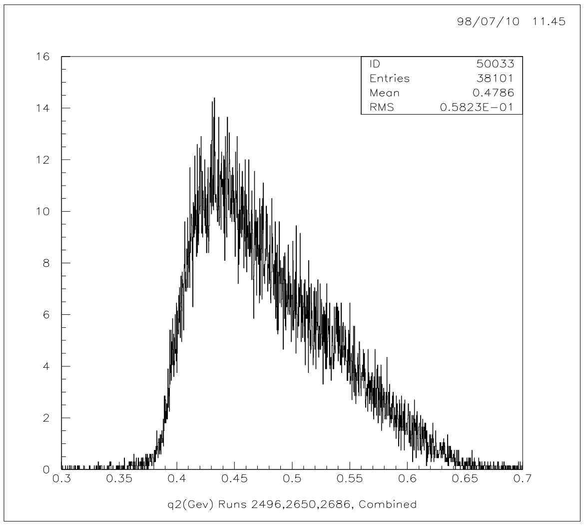
  Comissioning phase

Target polarization	5 %
Intensity dependence	3 %
Target angle	2.5 %
Total	7 % ($\Rightarrow$ 3%)

$$P_e = 0.385 \pm 0.027$$

Determination of Q^2

- **Dedicated runs**
  Spectrometer detector package



- **Technique**
  Optimization of optics
  Attenuation of light

$$< Q^2 >= 0.47(\mathrm{GeV/c})^2$$

- **Error : 3 % (⇒ <1%)**

Summary of the experiment

- **Experimental errors**

	Error
Beam polarization	7 %
Q^2 determination	3 %
Backgrounds	2 %
Spectrometer alignment	1 %
Finite acceptance	1 %
Helicity correlations	$<$ 0.2 %

- **Preliminary result :**

  $Q^2 = 0.47$ (GeV/c)^2, θ = 12.5 °

$$\mathcal{A}_{\mathrm{PV}}(\mathrm{ppm}) = -14.7 \pm (1.9)_{\mathrm{stat}} \pm (1.1)_{\mathrm{syst}}$$

Theoretical prediction

- **Form factors**

  Use dipole approximation

  Galster parametrization for G_E^n

- **Errors**

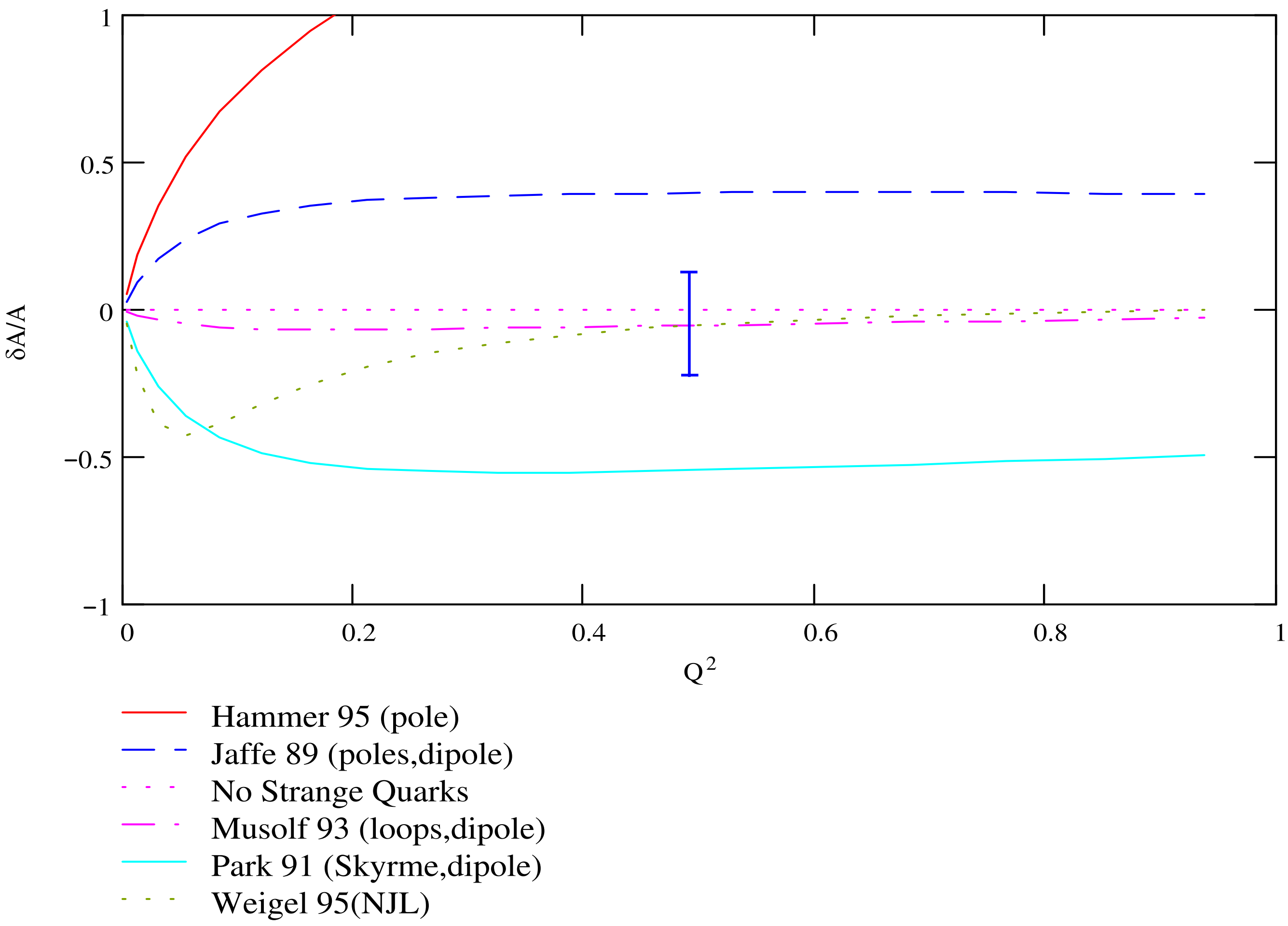
	Error
G_E^n (50 % variation)	9.6 %
Other form factors	4 %
Axial radiative corrections	1.4 %
Vector radiative corrections	0.5 %

$$\mathcal{A}_{\rm th}(\rm ppm) = -15.6 \pm (0.7)_{\rm syst} \pm (1.6)_{G_N^e}$$

Sensitivity of the measurement

- **Difference of asymmetries :**

$$\Delta\mathcal{A}(\text{ppm}) = 0.9 \pm (1.9)_{\text{stat}} \pm (1.3)_{\text{syst}} \pm (1.6)_{G_N^e}$$



- **Goal for next year's run**

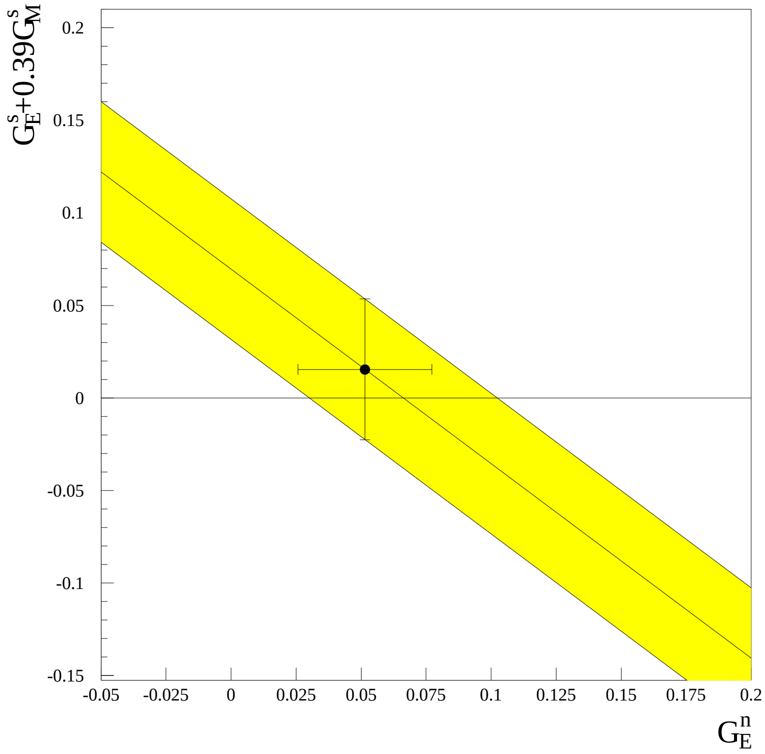
  $\Rightarrow \Delta A/A = 8\%$

Strangeness content of the proton

- **Vector strange form factors**

$$G_E^s + 0.39 G_M^s = 0.016 \pm 0.048$$

- **Sensitivity to G_N^e**



- **Previous measurements :**
  - ⇒ **All consistent with no strangeness**
  - ⇒ **Less sensitive**

Conclusions

- **Strange effects seem to be small**

- **Improvements for next run**
  - $\Rightarrow$ **Statistics ...**
  - $\Rightarrow$ **Better precision on** G_N^e
  - $\Rightarrow$ **Compton polarimeter**

    see talk of T. Pussieux

- **A very nice tool**
  - $\Rightarrow$ **Robust : Beam quality**
  - $\Rightarrow$ **Fast : Integration**

- **A broad physics program ahead**
  - $\Rightarrow$ **Separation** G_E, G_M
  - $\Rightarrow$ Q^2 **Dependance**
  - $\Rightarrow$ **Neutron radius**
  - $\Rightarrow$ **Tests of the Standard Model**