N*'s and GPDs

1/ ΔVCS

2/ N-Δ Form Factor

Theoretical aspects
& First Look At JLab Data

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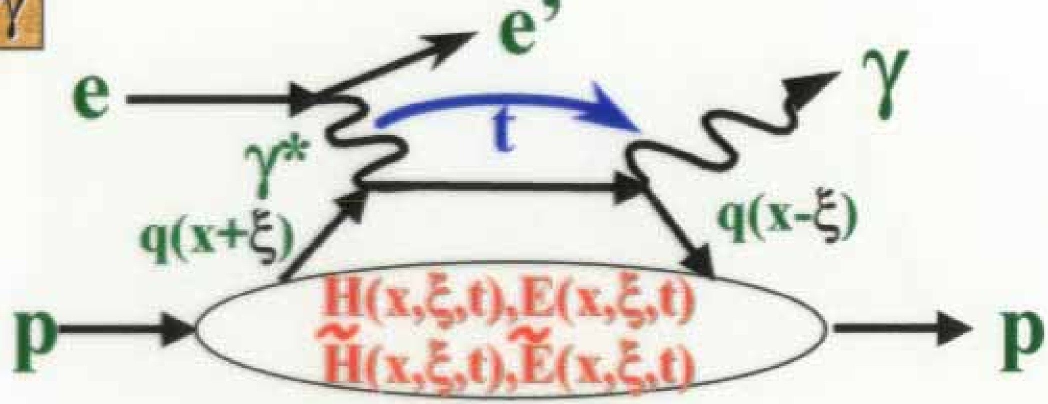
Resonant DVCS

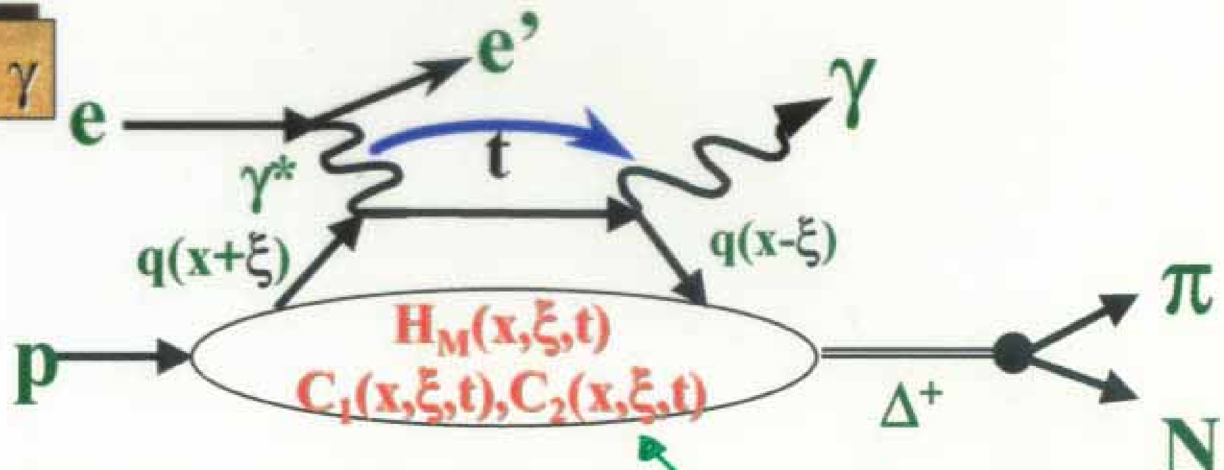
$e + p \Rightarrow e + p + \gamma$

DVCS



$e + p \Rightarrow e + \Delta^+ + \gamma$

R DVCS:
ΔVCS



(Frankfurt, Polyakov, Strikman, Vanderhaeghen) large N_c limit

Resonant DVCS

- New flavor decomposition

  ➡ <u>Complementary to DVCS</u>

  In the large Nc limit : $C_1 \sim \tilde{H}$ $C_2 \sim \tilde{E}$ $H_m \sim E$

  DVCS : $E = 4/9E^u + 1/9E^d$

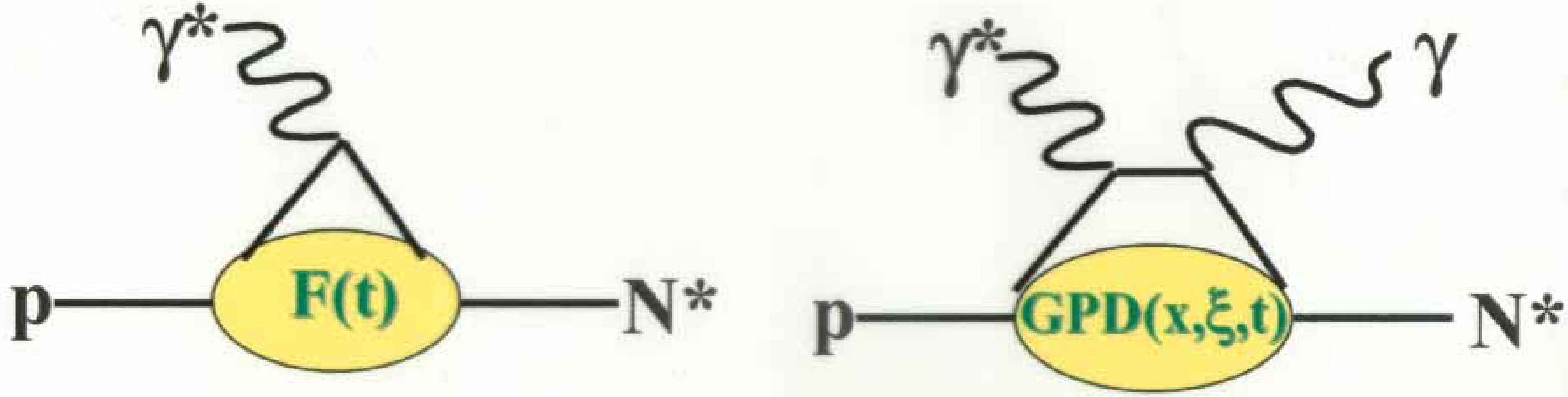
  ΔVCS : $E = E^u - E^d$

- Quark flavor separation using different combination for $E, \tilde{H}$ & $\tilde{E}$

- Potentially, access to quark distributions in Δ, orbital momentum contribution of quarks in Δ,…

- More generally, « new spectroscopy », 3-d picture of baryon resonances.

« Resonant » DVCS :
New/Hard spectroscopy

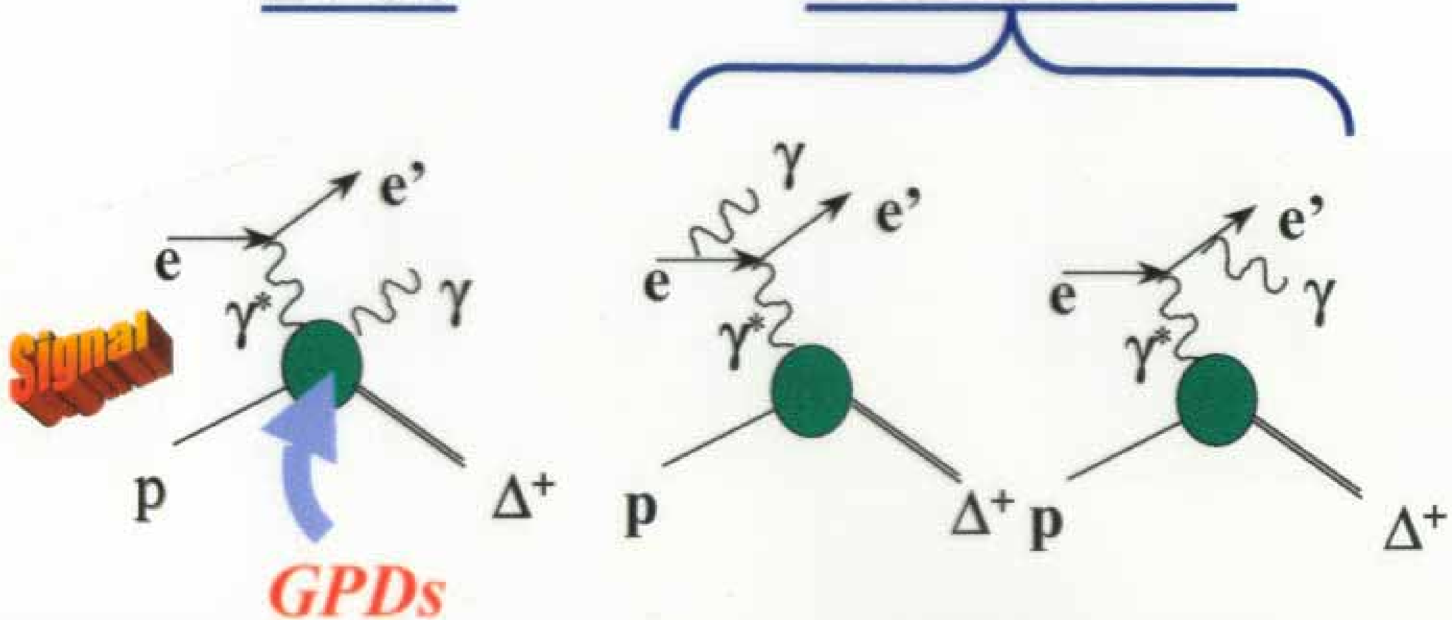


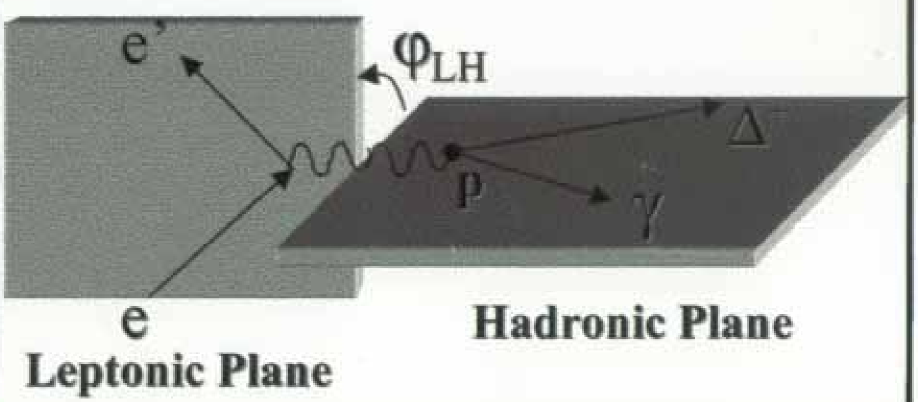
$$F(t) = \int GPD(x,\xi,t)\,dx$$

x: Longitudinal momentum fraction of the quark
ξ: Longitudinal transfer (Skewdness)

Beam Spin Asymmetry

ΔVCS **Bethe-Heitler**



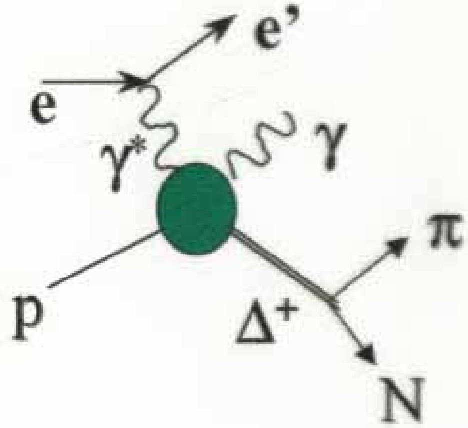


BH dominance makes it difficult to extract ΔVCS signal at "low" energies (BH = 5 x ΔVCS) …

BUT <u>Interference of the two process</u> leads to a <u>spin asymmetry</u> as a function of φ_{LH}

Final States Detection

(S. BOUCHIGNY - IPN ORSAY - analysis)



ΔVCS reaction

Δ^+ decays in p, π^0

Detection: e^-, proton, $\gamma1$, $\gamma2$

Δ^+ decays in n, π^+

Detection: e^-, neutron, π^+

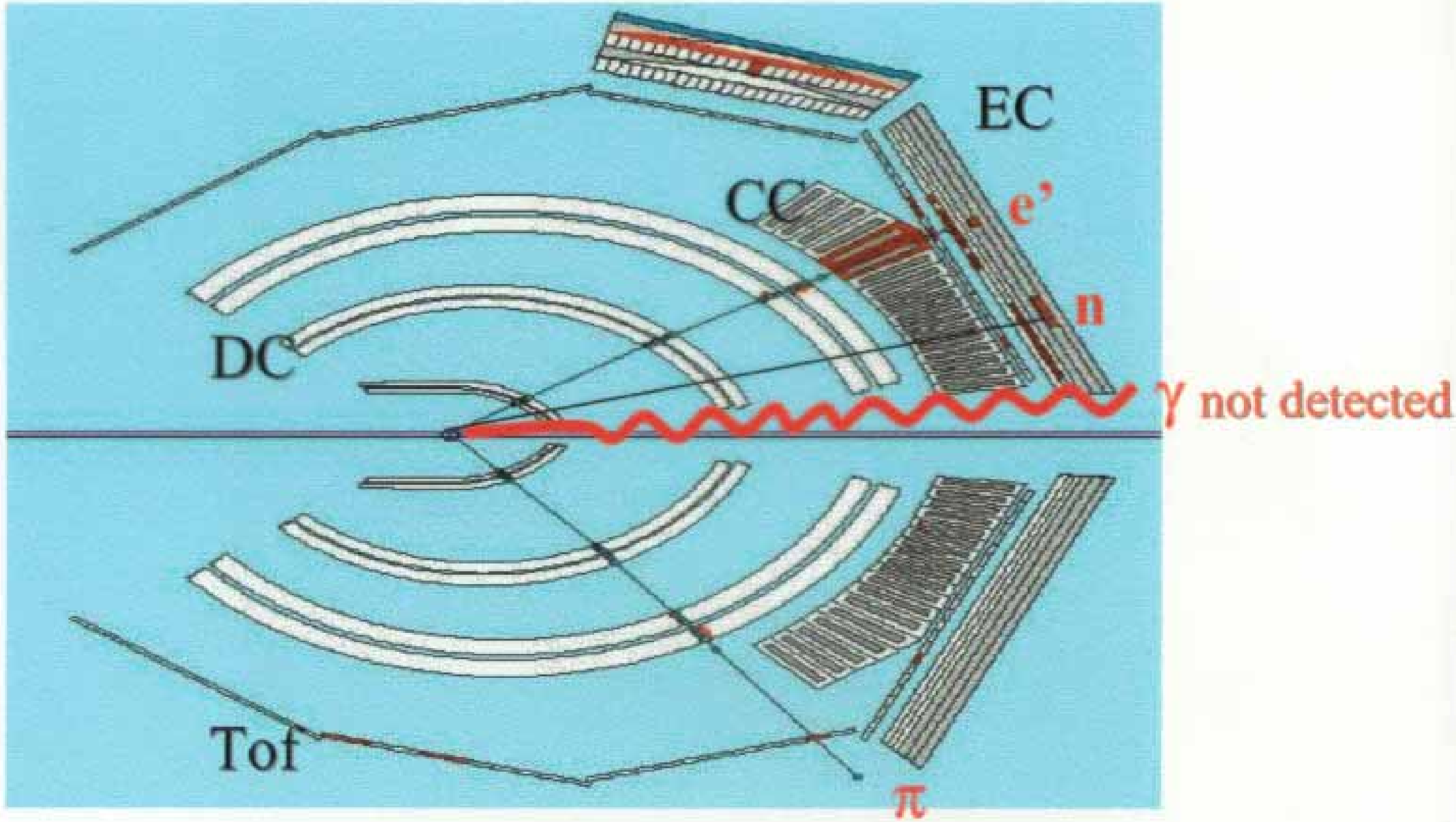
Alternative Approach:

Detection: e^-, γ, π^+

e^-, γ, proton

➡ We focus on e^-, neutron, π^+ final state.

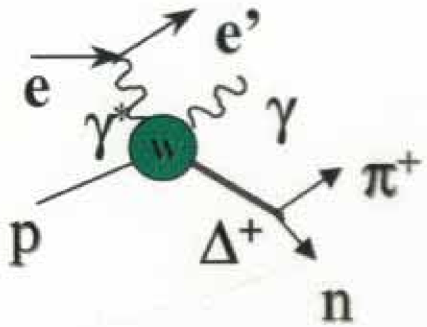
Particle Detection



Electrons: DC, EC, CC
Neutrons: EC + Tof

π+: DC + Tof
γ: EC

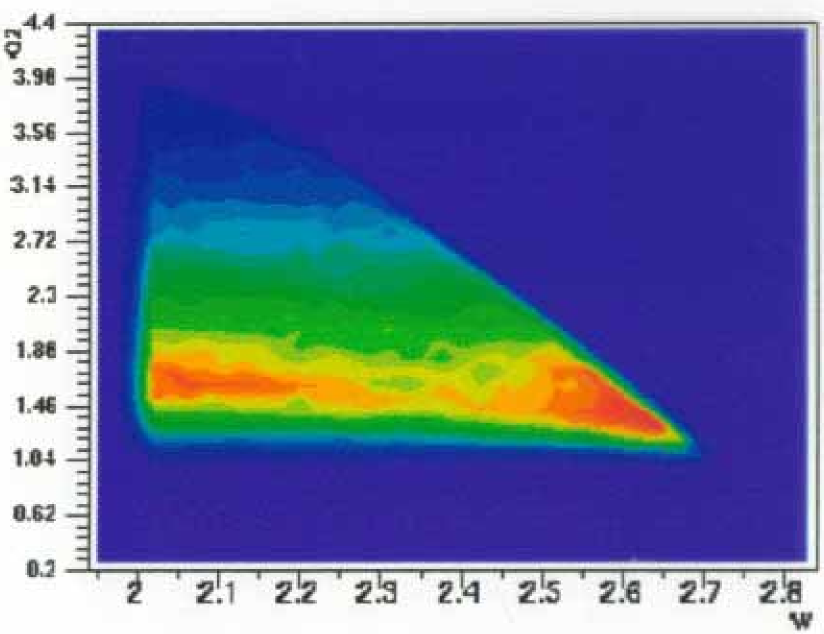
Phase Space



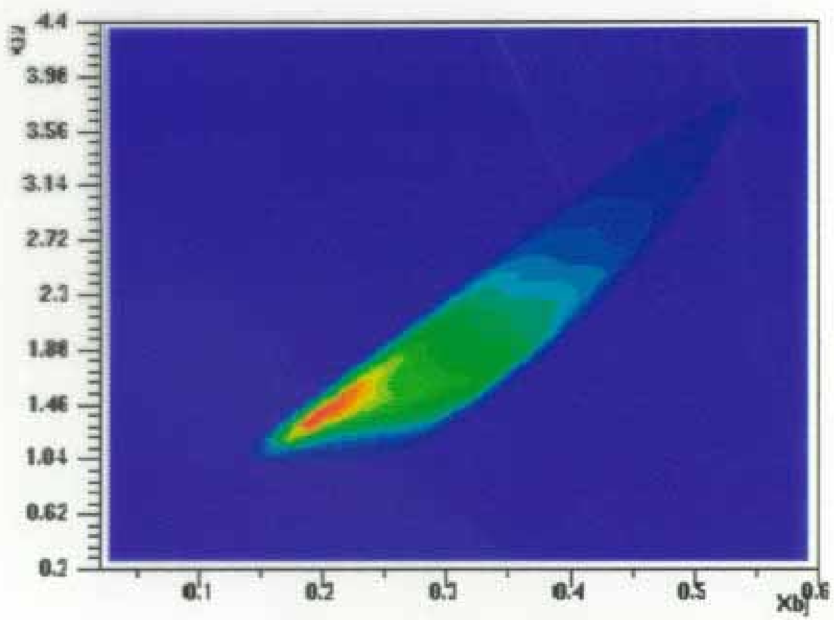
Ebeam = 4.72 GeV

W > 2

Xbj~0.2 → SSA ~ 5%

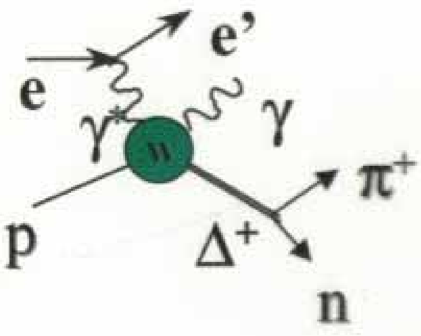


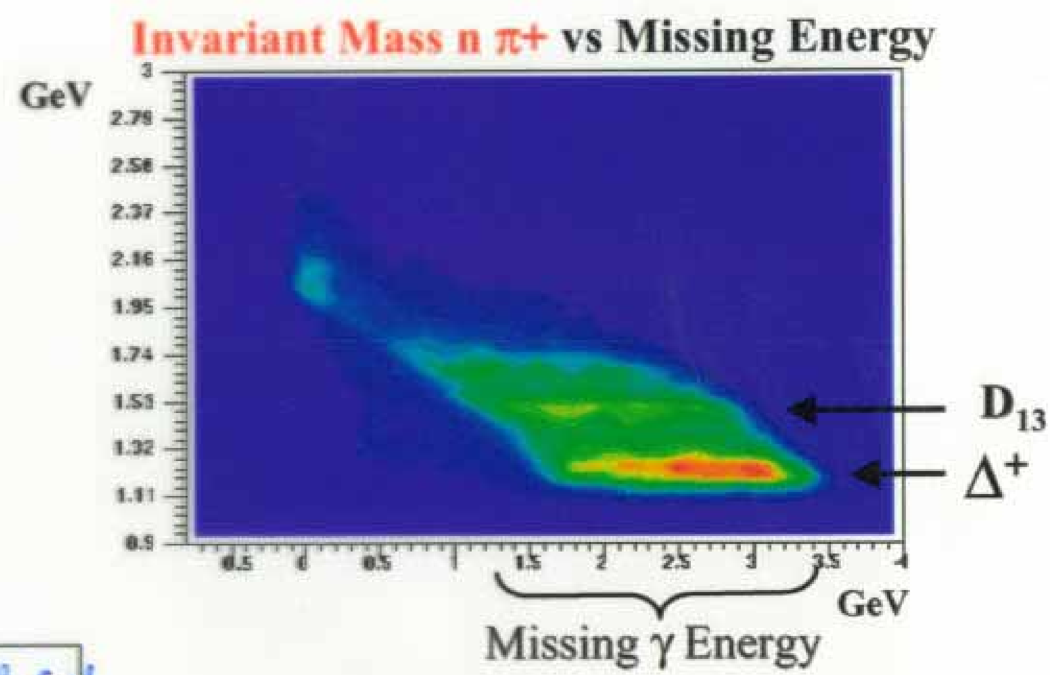
Q2 vs W (GeV)

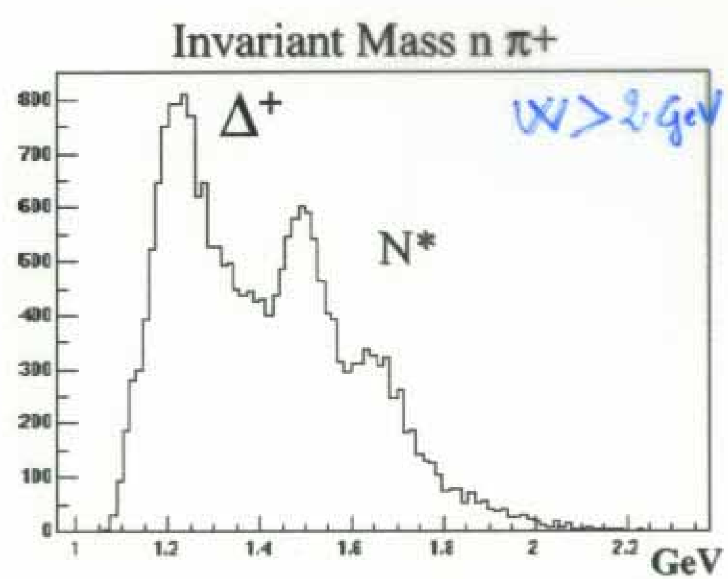


Q2 vs Xbj (GeV)

Selecting the Δ

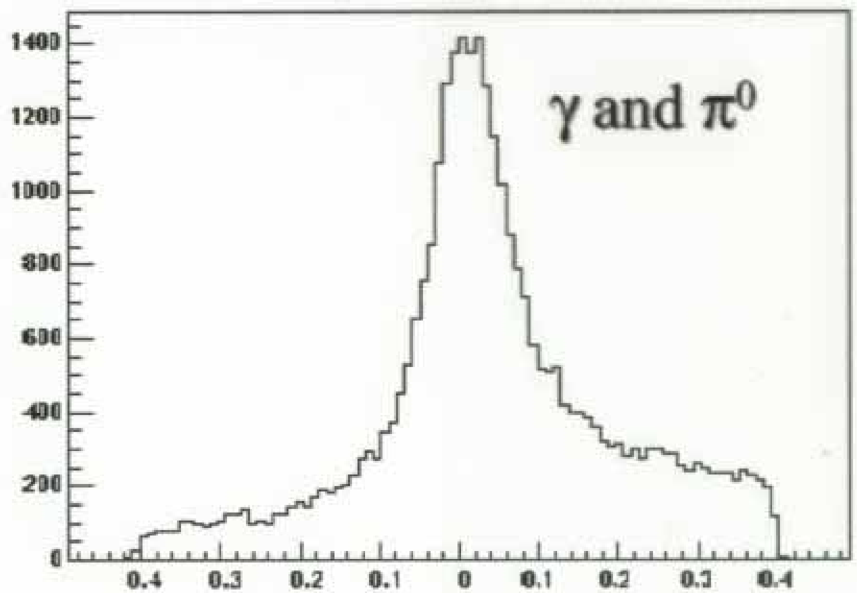




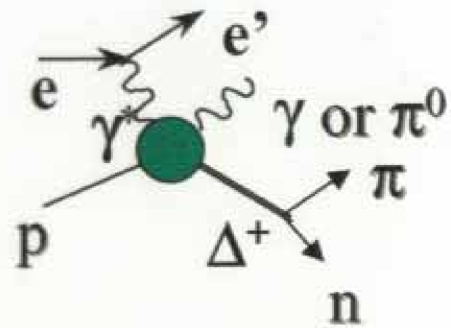


Selecting the Scattered γ

γ's from ΔVCS are produced with very small angle and cannot be detected. We select them through missing mass and missing energy calculation.



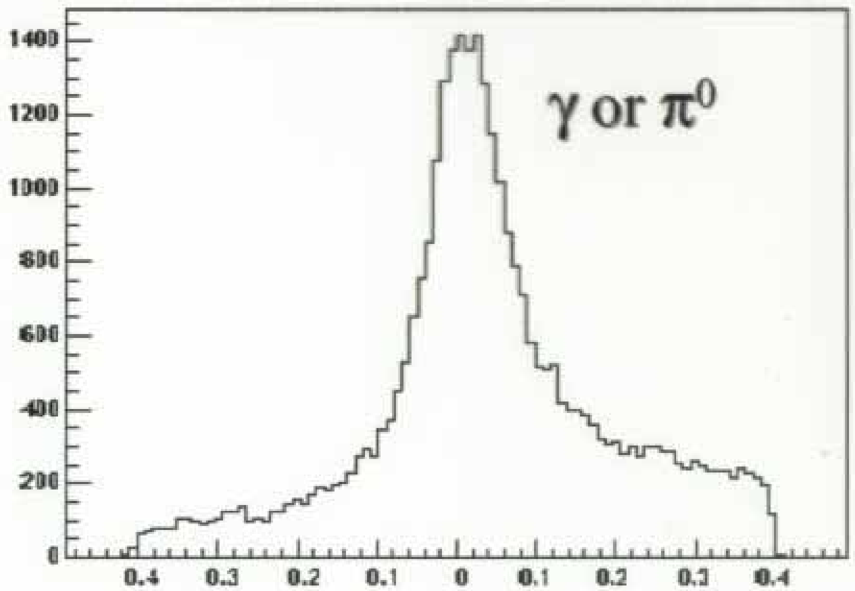
Missing Mass² (e n π^+)



This peak contains γ and π^0
At these energies, resolution is not enough to separate the two peaks.

$\gamma\ \pi^{0}$ separation

Strategy: fit this peak by two gaussian functions (one for the γ, one for the π^0) plus a polynomial function for the background.



Missing Mass^2 (e n π^+)

But we need to know precisely what are the mean and the sigma of each of the gaussian.

- Not enough data yet to complete SSA extraction, but encouraging signals
- Analysis of a e1-6 experiment is under way: 10 times more data is expected (~25000) at 6 GeV. Results soon.
- A specific calorimeter is designed to detect the missing γ (Experiment at the end of 2003).

LINK between GPD's & FF's

$$F_1^q = \int_{-1}^{+1} H^q(x, \xi, t)\, dx$$

$$F_2^q = \int_{-1}^{+1} E^q(x, \xi, t)\, dx$$

Take $\xi = 0 \Rightarrow$ model for $H(x, 0, t)$ & $E(x, 0, t)$
(with $H(x, 0, 0) = q(x)$)

Low t: $(-t \lesssim 1\ \mathrm{GeV}^2)$: REGGE Ansatz
(Goeke, Polyakov, Vdh 01)

$$F_1^u(t) = \int_0^{+1} u_v(x) \frac{1}{x^{\alpha_1' t}}\, dx$$

$$F_1^d(t) = \int_0^{+1} d_v(x) \frac{1}{x^{\alpha_1' t}}\, dx$$

$$\Rightarrow F_1^p = e_u F_1^u(t) + e_d F_1^d(t)$$

$$F_1^n = e_u F_1^d(t) + e_d F_1^u(t)$$

Similarly: $$F_2^q(t) = \int_0^{+1} \kappa^q\, q_v(x) \frac{1}{x^{\alpha_2' t}}\, dx$$

$\Rightarrow$ 2 free parameters : α_1', α_2' $\Rightarrow$ (constrained around $\sim 1\ \mathrm{GeV}^2$)

$\Rightarrow$ fit 4 FF's : $G_{E,M}^{p,n}$ (G_M^A)

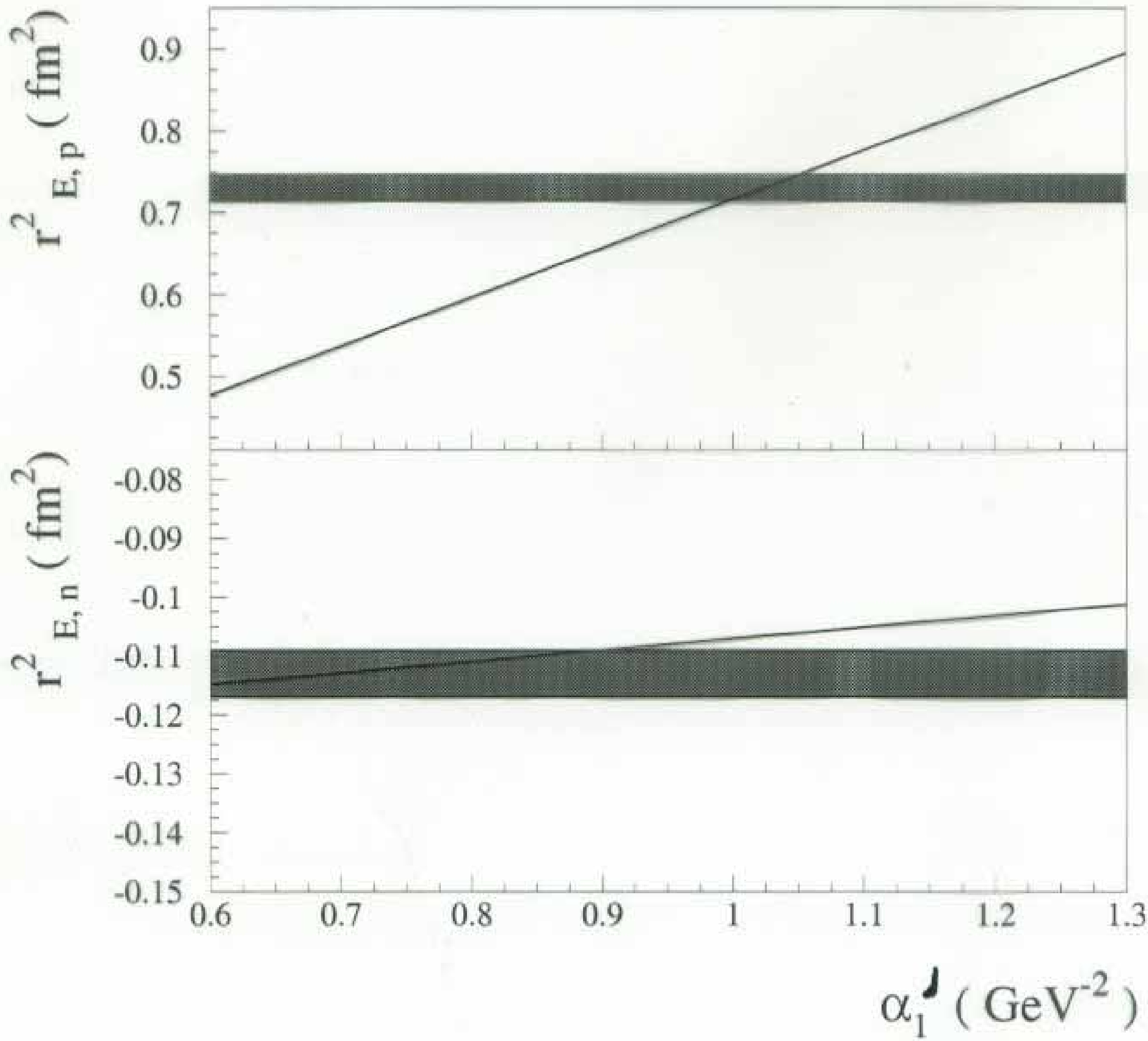
PROTON and NEUTRON electric charge radii

$$F_1^q(t) = \int_0^1 dx\, q_v(x)\, \frac{1}{x^{\alpha' t}}$$

($q_v(x)$ from MRST01)

$$r^2_{1,p} = -6\,\alpha'_1 \int_0^1 dx\, \ln x \left\{ e_u u_v + e_d d_v \right\}$$

$$r^2_{E,N} = r^2_{1,N} + 3/2\, \kappa_N / m^2_N$$

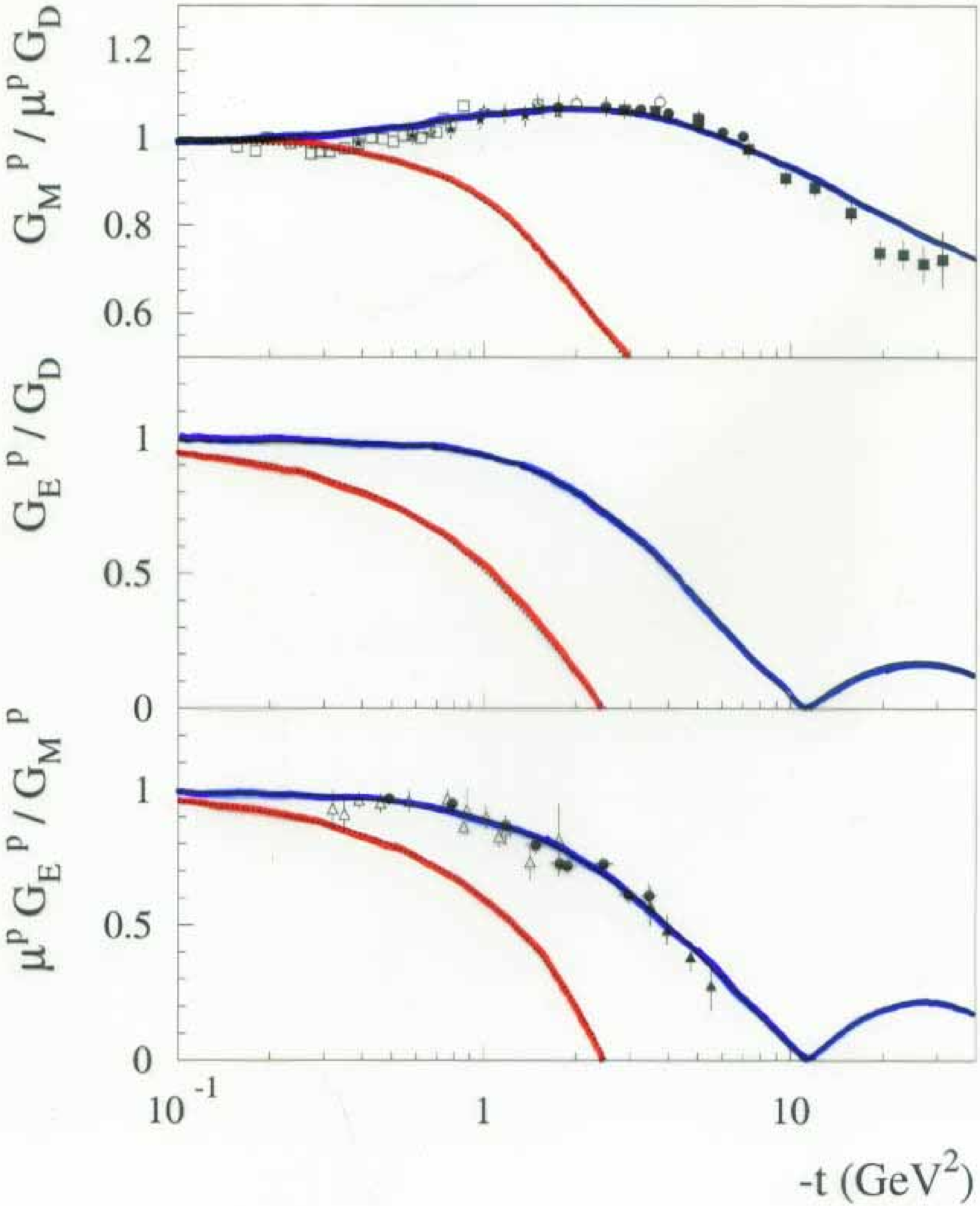


$\alpha'_1 \sim 1.\ \mathrm{GeV}^{-2}$

→ compatible with standard Regge slopes.

PROTON electric and magnetic form factors

work in progress : M. G., M. VdH, M. Polyakov

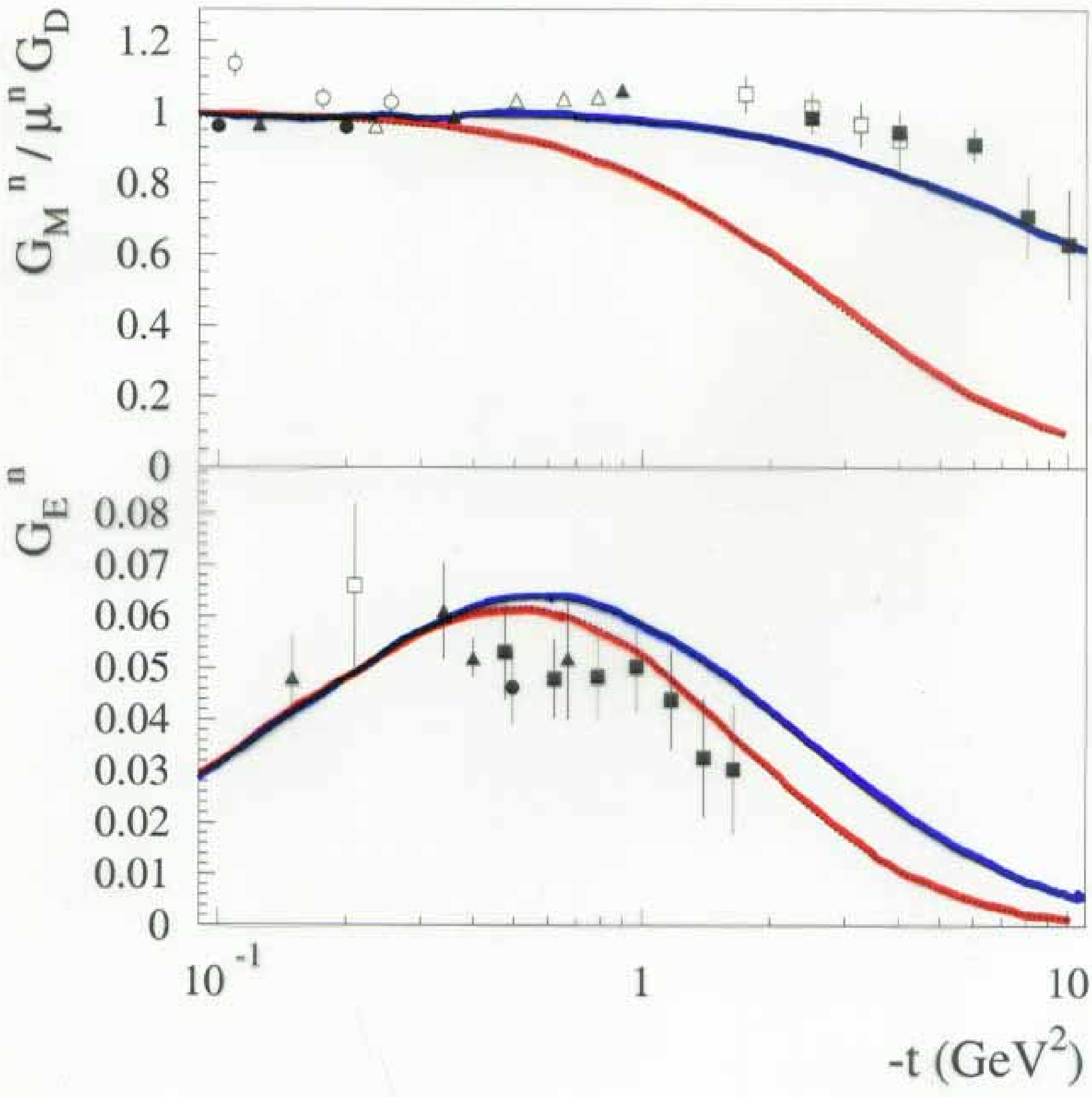


- "low t" (linear traj.) model

- "large t" (non-linear traj.) model

NEUTRON electric and magnetic form factors

work in progress: M.G., M.Vdh, M. Polyakov



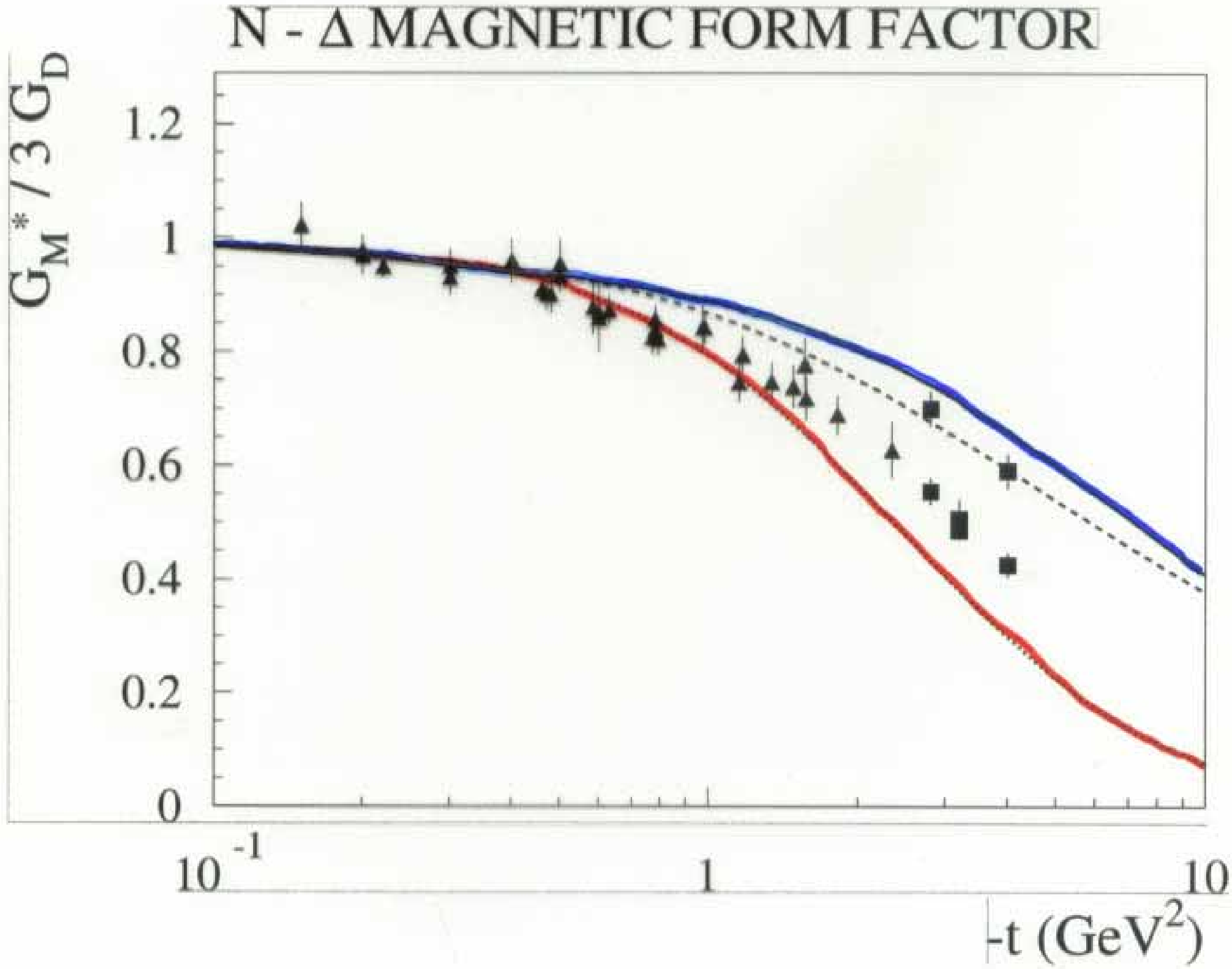
- "low t" (linear traj.) model

- "large t" (non-linear traj) model

⇒ large N_c : H_M
C_1, C_2

(Frankfurt, Polyakov, Strikman, VdH '00)

$$H_M(x,\xi,t) = \frac{2}{\sqrt{3}} \left\{ \underbrace{E^u(x,\xi,t) - E^d(x,\xi,t)}_{\text{nucleon GPD's !}} \right\}$$

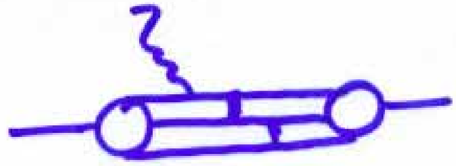


- "low t" (linear traj.) model

- "large t" (non-linear traj.) model

Large / extended t domain:

pQCD:



$F_1(t) \underset{-t \gg}{\sim} 1/t^2$

F_2 (helicity flip) $\underset{-t \gg}{\sim} 1/t^3$

1] Introduce non-linear Regge trajectories:

$$\alpha(t) = \alpha(0) + \alpha' 2T \left[1 - \sqrt{1 - t/T} \right]$$

(Brisudova, Burakovsky, Goldman, 2000)

T: non-linearity (free) parameter

$$\Rightarrow F_1(t) \sim 1/t^2$$

2] a/ x-dependence of E^q not constrained

b/ large t power behavior is fixed by large x behavior:

$\Rightarrow$ large x behavior of $\underline{\underline{E}}$ should be different from $\underline{\underline{H}}$

$(F_2 \sim 1/t^3)$ $\qquad$ $(F_1 \sim 1/t^2)$

$$F_2^q(t) = \int_0^1 dx \, (1-x)^{\eta_q} \, q_v(x) \, \frac{1}{x^{\alpha' t}}$$

6 parameters: $\alpha'_1, \alpha'_2, \eta^u, \eta^d, T_1, T_2$

Fit $G^{p,n}$