Exclusive real Compton scattering (RCS) at **12 GeV**

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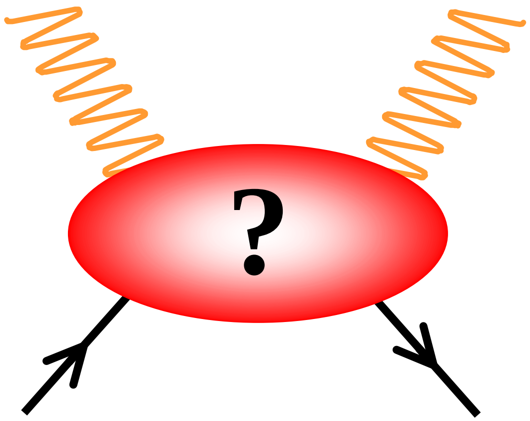
"Exclusive reactions at JLab
with 12 GeV beam" workshop



- **Why ?**

- **How ?**

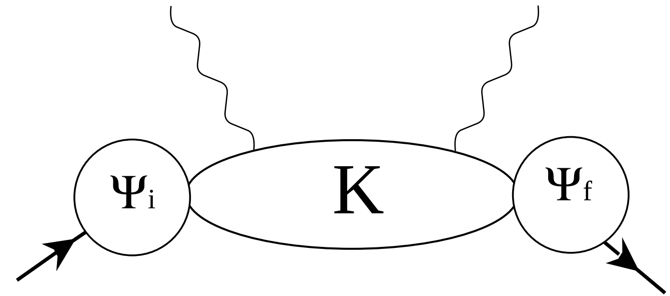
Factorization at the hard scattering limit (s, -t, -u >> M^2)

(for RCS)

Factorization of the transition amplitude into the convolution of a perturbative hard scattering amplitude with an overlap of the initial and final soft wave functions

Schematically:

$$T_{if}(s,t) = \Psi_f \otimes K(s,t) \otimes \Psi_i$$

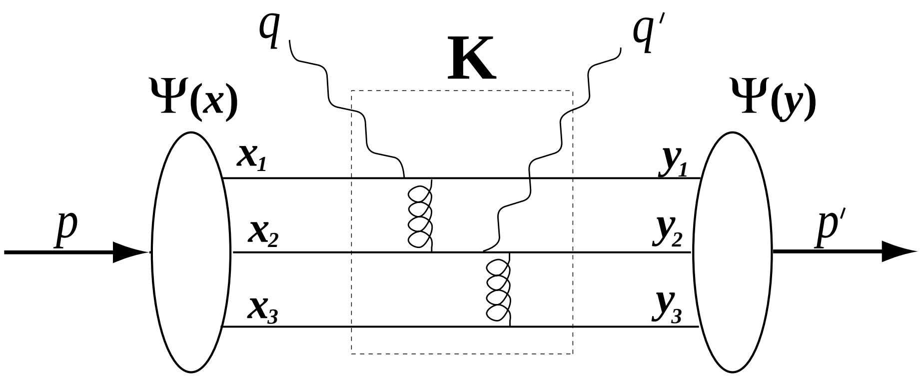


1. What can we learn about the hard scattering mechanism ?
   - How many active quarks ? (pQCD, diquark, handbag, …)
   - How is the momentum shared among those quarks ?

2. What can we learn about the proton structure (Ψ) ?
   - Constraints on the distribution amplitudes
   - New form factors linked to skewed parton distributions (SPD's)

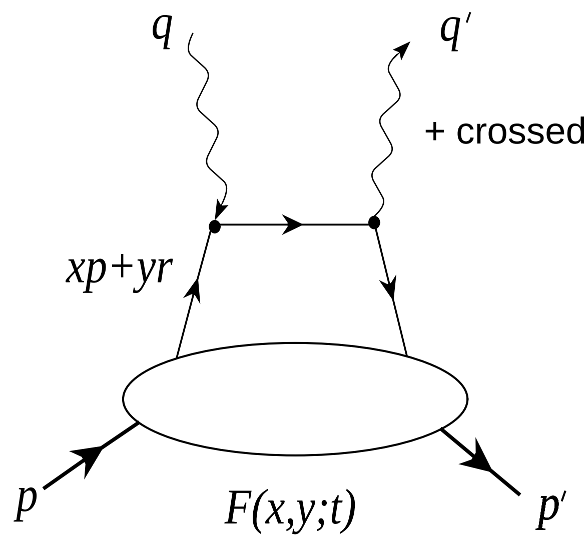
3. Intense recent theoretical activity and existing data limited (Cornell 1979)

2 different RCS hard scattering mechanisms



Asymptotic (pQCD) mechanism

- 3 active quarks
- momentum shared by <u>hard gluon exchange</u>
- scaling: $\frac{d\sigma}{dt} = \frac{f(\theta_{cm})}{s^6}$
- soft physics in <u>distribution amplitudes</u>
- **dominates at "high enough" energy**



Soft overlap mechanism

- handbag dominates: 1 active quark
- momentum shared by <u>soft overlaps</u>
- scaling: σ / σ_{KN} s-independent at fixed t
- soft physics in skewed parton distributions (SPD's)

$\longrightarrow$ <u>2 new form factors</u>: R_A and R_V

+ predictions on polarization transfer observables

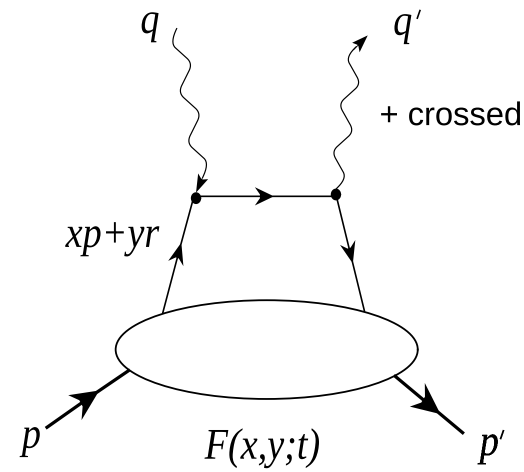
RCS and Skewed Parton Distributions (SPD's)

Soft overlap mechanism

at skewedness parameter = 0

$$\frac{d\sigma}{dt} = \left(\frac{d\sigma}{dt}\right)_{KN} \left[f_V R_V^2(t) + (1 - f_V) R_A^2(t) \right],$$

with $f_V = \dfrac{(\tilde{s} - \tilde{u})^2}{2(\tilde{s}^2 + \tilde{u}^2)}$, $\tilde{s} = s - m^2$, $\tilde{u} = u - m^2$



Lepton scattering

Compton scattering

$$F_1(t) = \Sigma_a e_a \int_0^1 \mathcal{F}^a(x;t)dx \qquad R_V(t) = \Sigma_a e_a^2 \int_0^1 \mathcal{F}^a(x;t)\frac{dx}{x}$$

Dirac form factor

$$F_2(t) = \Sigma_a e_a \int_0^1 \mathcal{K}^a(x;t)dx \qquad R_T(t) = \Sigma_a e_a^2 \int_0^1 \mathcal{K}^a(x;t)\frac{dx}{x}$$

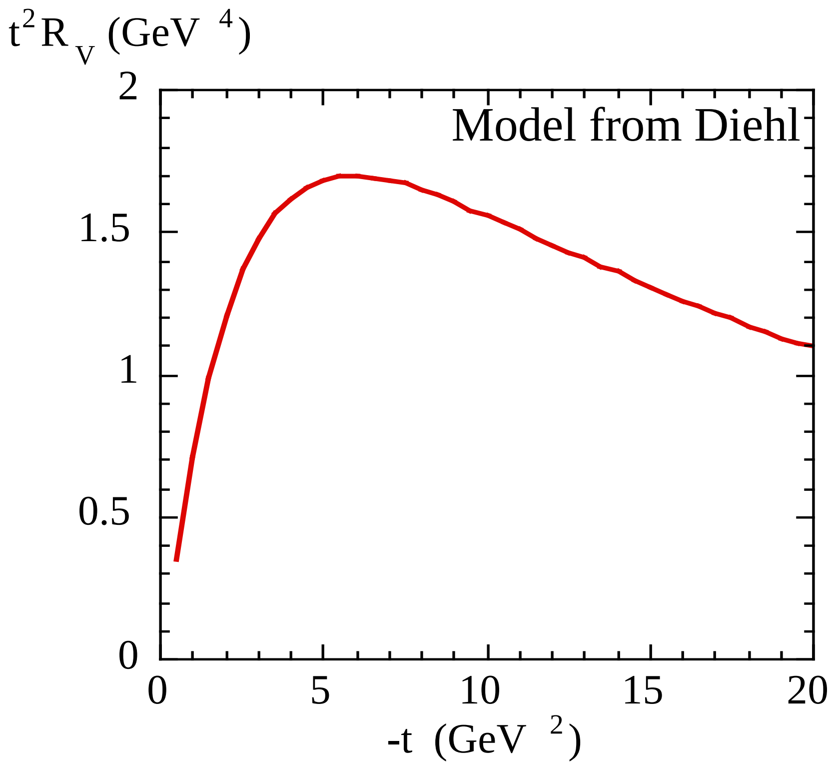
Pauli form factor

$$G_A(t) = \boxed{\Sigma_a e_a} \int_0^1 \mathcal{G}^a(x;t)\boxed{dx} \qquad R_A(t) = \boxed{\Sigma_a e_a^2} \int_0^1 \mathcal{G}^a(x;t)\boxed{\frac{dx}{x}}$$

Axial form factor

RCS form factors

- As fundamental as elastic form factors G_{Ep}, G_{Mp} etc.
- Connected to SPD's (constraints to models)
- Have to be measured at high $-t$
- E99114 measures up to $-t$ = 6 GeV^2



- $R \sim 1/t^2$ for $-t$ = 3-10 GeV^2

  $\Rightarrow$ $1/s^6$ scaling of X-section
- Asymptotically $R \sim 1/t^4$

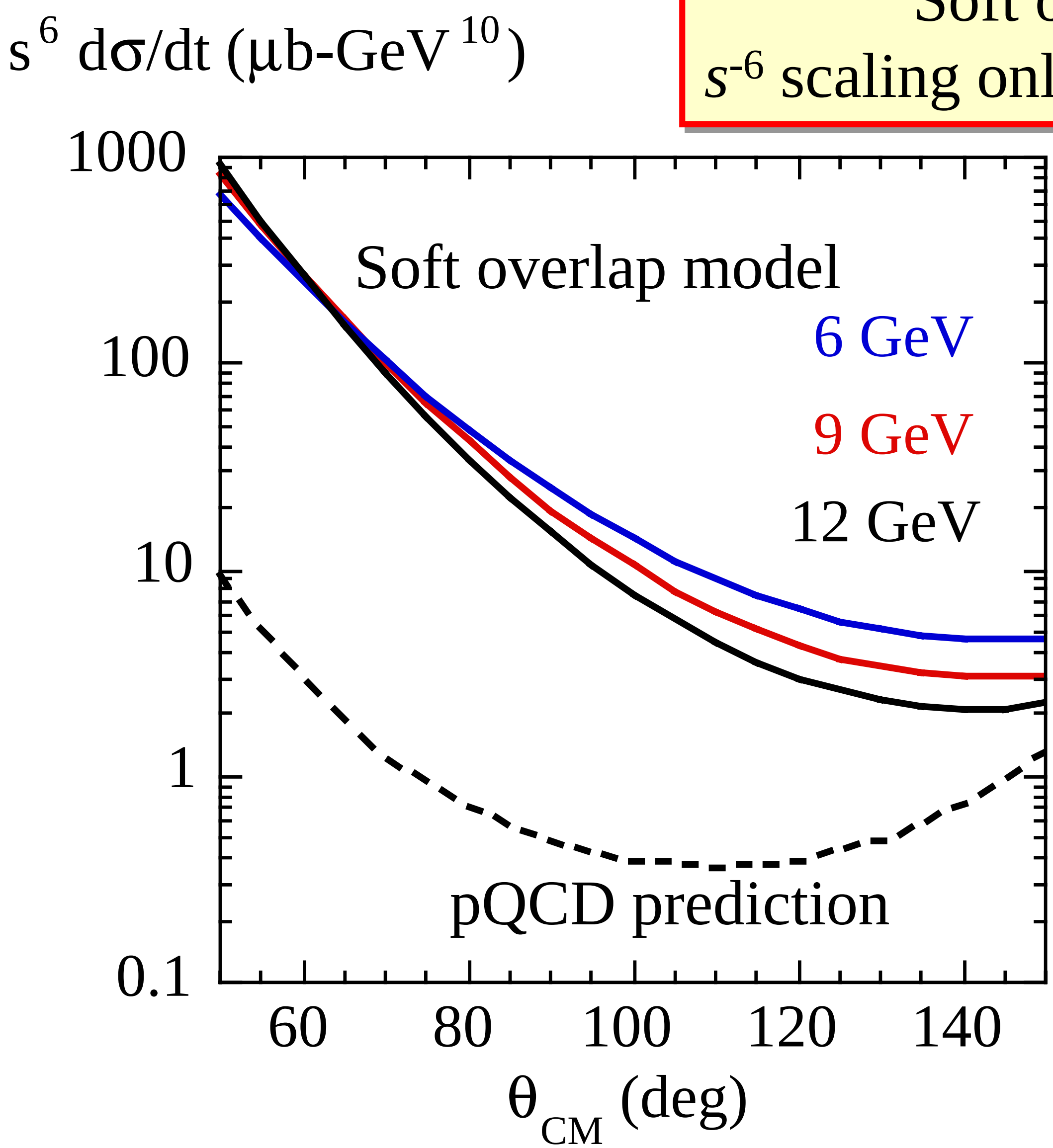
  $\Rightarrow$ $1/s^{10}$ scaling of X-section

  $\Rightarrow$ subdominant

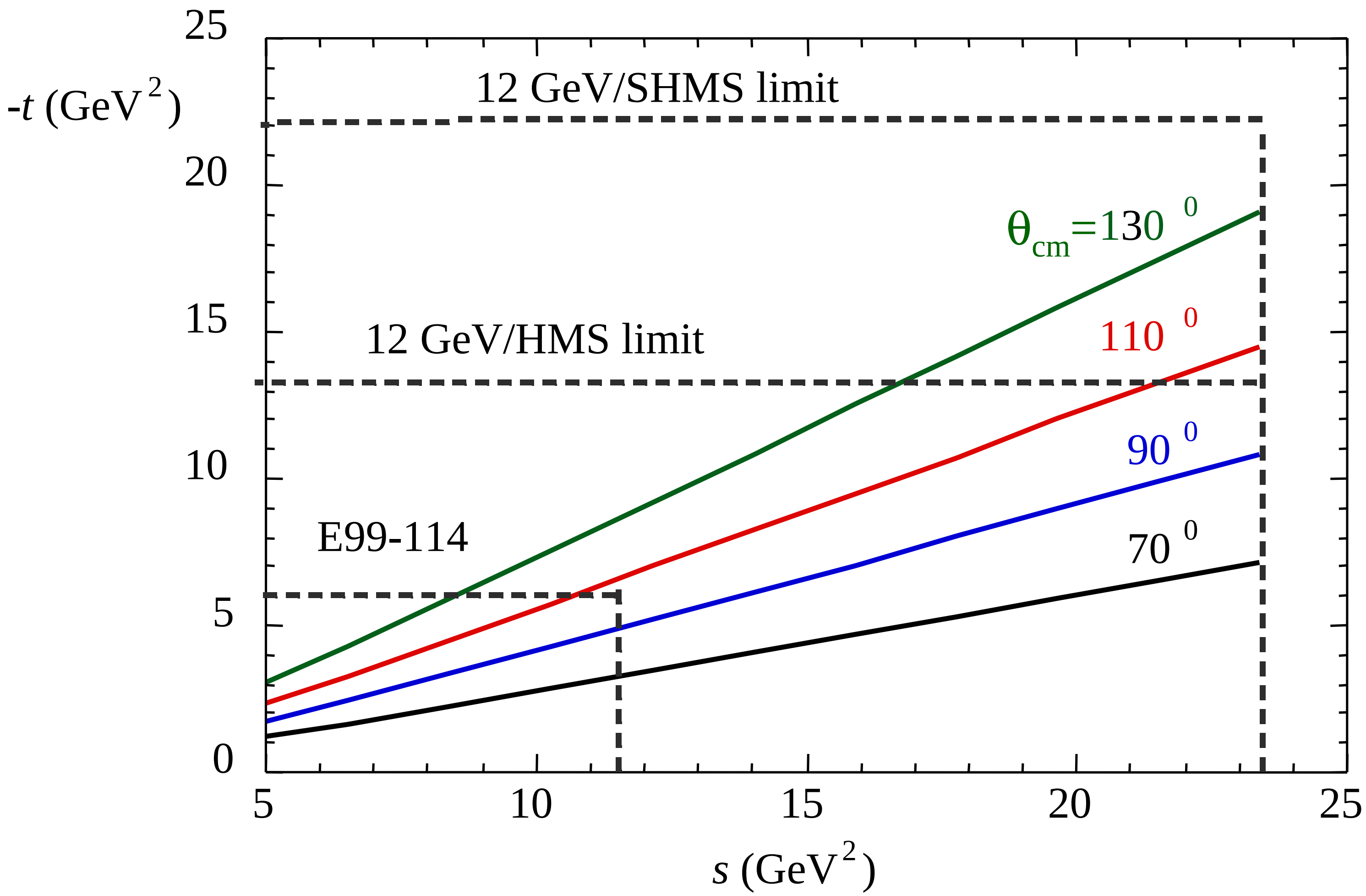
  compared to pQCD

Scaling at fixed θ_{cm}

Soft overlap:
s^{-6} scaling only **approximate**



What kinematics with a 12 GeV beam



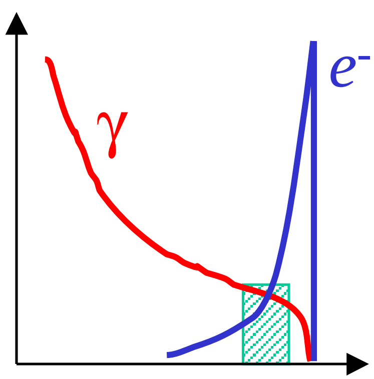
Experimental setup

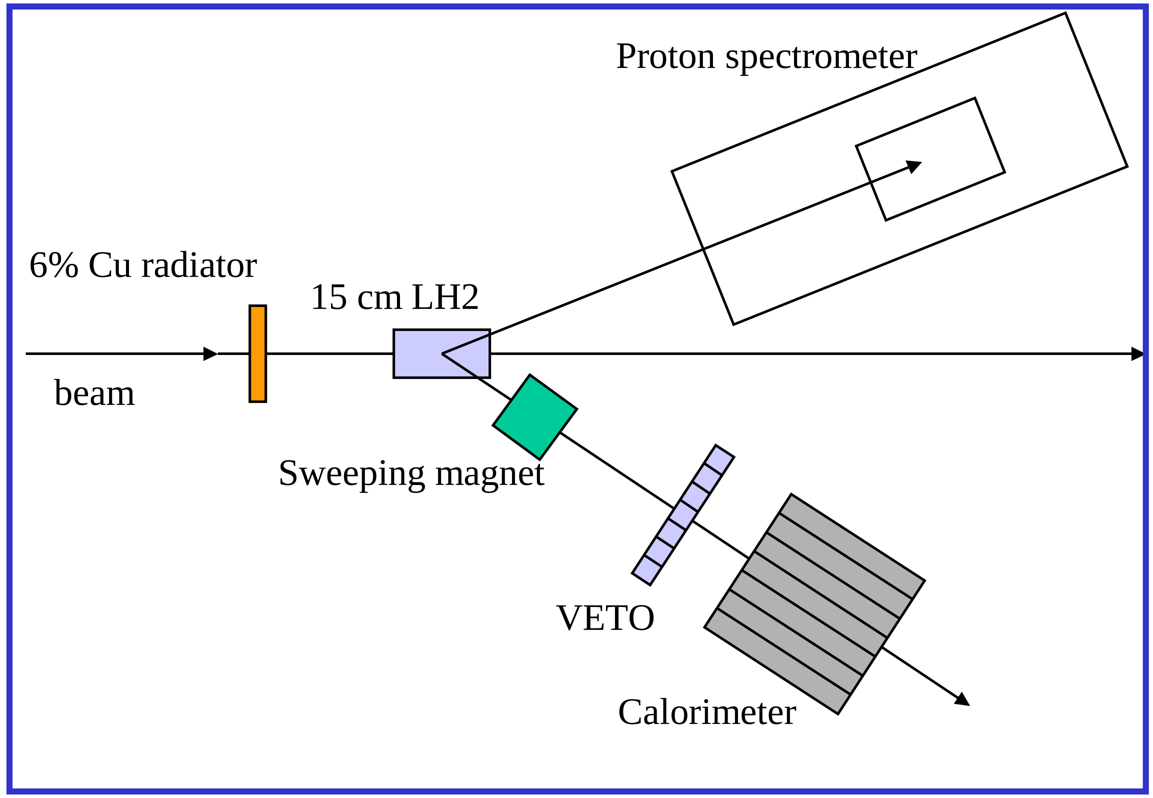
Kinematics range:

$E \leq 6$ GeV

$6 \leq s \leq 12$ GeV^2

$1.5 \leq -t \leq 7$ GeV^2





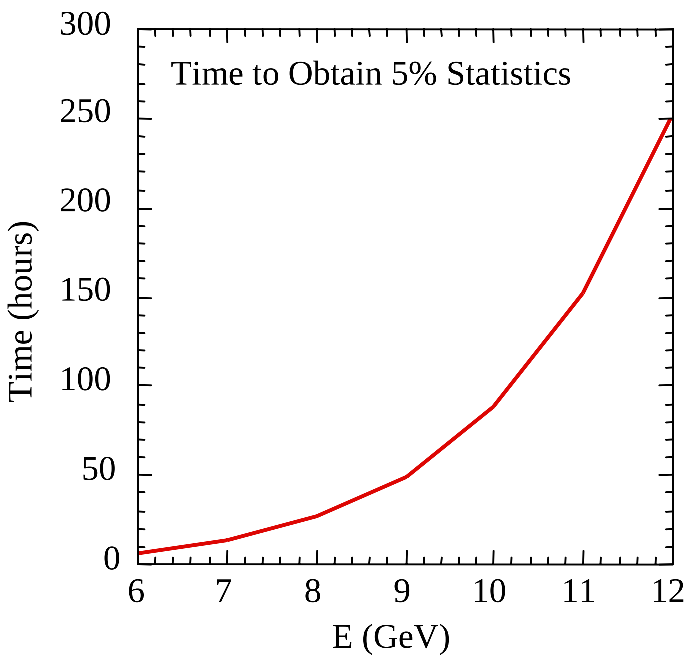
- Mixed e^--γ beam
- High luminosity (>10 μA beam and radiator close to the target)
- Good angular resolution required to handle $\pi^0 \rightarrow \gamma\gamma$ background

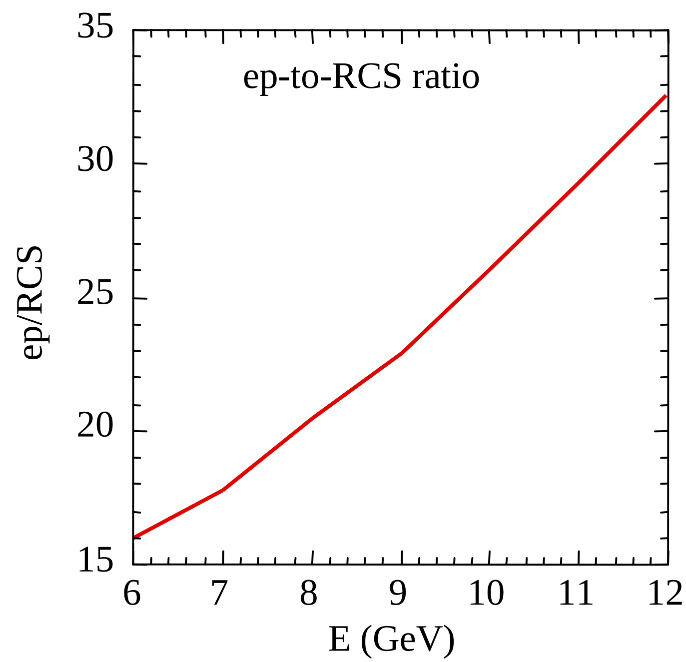
⇨ segmented calorimeter, accurate proton kinematics

- *ep* scattering: - deflection magnet + veto counter
  - calibration (energy and position with wire chamber)
  - normalization

Experimental issues at higher energy

- Cross-sections are small (s^{-6} behaviour !)
- Background from π^0 worse
  - $\pi^0 \rightarrow \gamma\gamma$ cone smaller but…
  - $(\gamma,\pi^0)/(\gamma,\gamma) \sim 1/s$
- Background from *ep* scattering worse (θ smaller) but manageable !
- Need MUCH more time for 5% statistical accuracy





A reasonnable compromise, 10 GeV beam with HMS

- s = 20 GeV^2
- θ_{cm} = 70°-120° => $-t$ = 6-13 GeV^2
- 6 data points, 5% statistical accuracy, 33 days of beam time
- Same measurement at 12 GeV (same θ_{cm})

  => 95 days !
- **Can run as soon as the energy is upgraded to 10 GeV !**

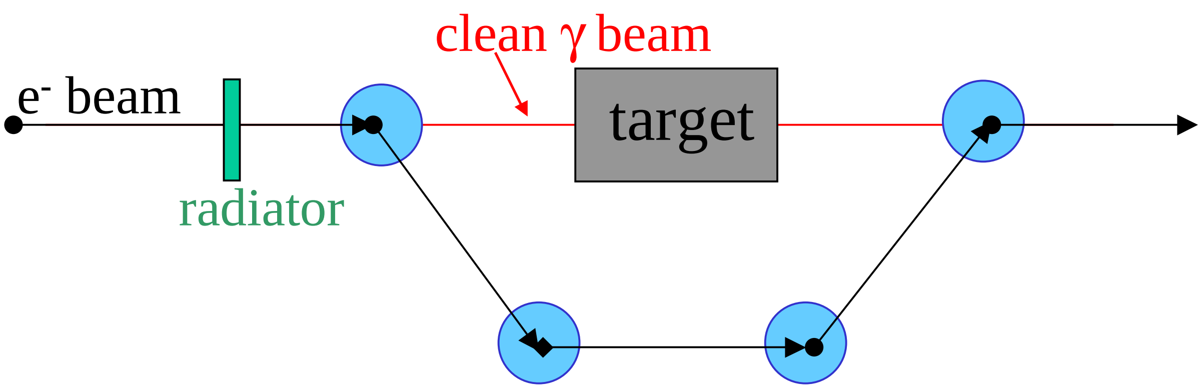
We will need a 2 m^2 radiation-hard, high resolution (and high granularity) electromagnetic calorimeter

For further measurements, at higher energy/luminosity

We need higher luminosity to go to higher energy:

Produce a clean γ beam with a **chicane**

- possibility of **higher L**
- no *ep* background
- polarized target possible =>**large asymmetry !**



To overcome spectrometer maximum momentum limitation:

=> use hadronic calorimeter + MWPC instead

- modest energy resolution
- good angular resolution

Summary and conclusions

- **RCS up to 10 GeV** allows measurements of new form factor up to $-t = 13\ \mathrm{GeV}^2$

- **E99114 technique** can be used in Hall C with the HMS
as soon as the energy is upgraded to 10 GeV !

- **Further measurements at higher energy** requires new ideas
(and we have some)