Experimental prospects for DDVCS with a new muon detector in Hall C

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PARTONIC STRUCTURE OF THE HADRONS

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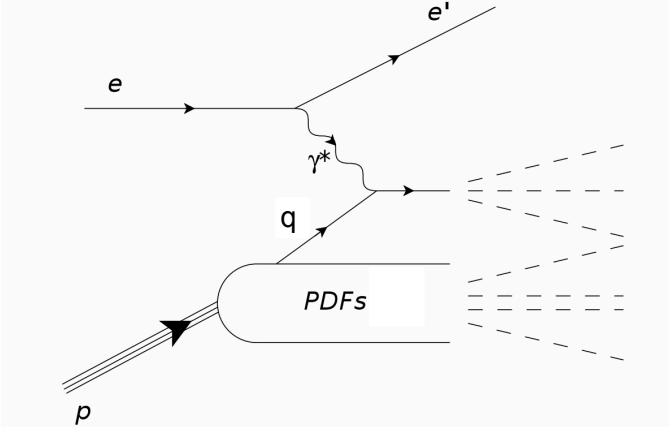
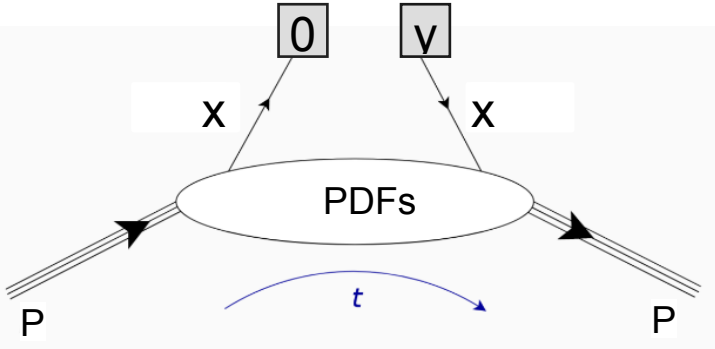
Deep Inelastic Scattering



DIS cross-section can be identified with the imaginary part of the forward amplitude of the doubly virtual Compton process



Non Local: two space-time points (0,y) are involved

QCD Matrix element : $$| < p | \bar{\psi}_q(0) \mathcal{O} \psi_q(y) | p > |_{y^+=\vec{y}_\perp=0}$$

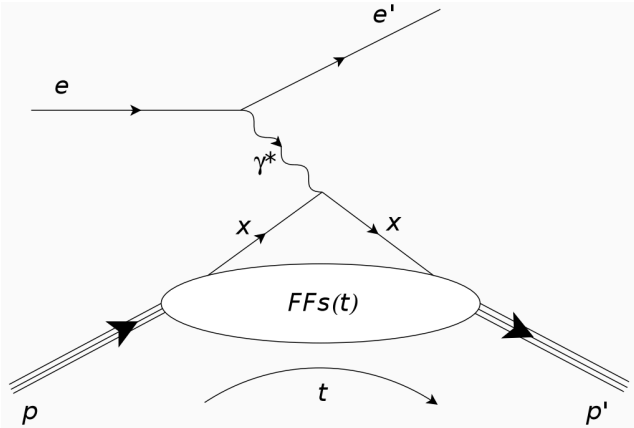
q : quark flavor (u,d,s)

ψ_q : quark field

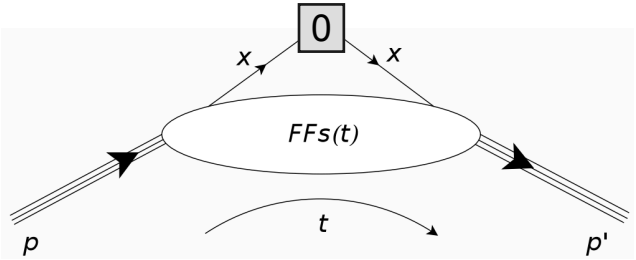
Forwards: Initial (p) and final (P) 4 momentum are same for the nucleon

1. SLAC, 60's

Elastic Scattering



The virtual photon interacts with the single quark which remains inside the nucleon but in this process the nucleon has changed its momentum



Local: one space-time points (0) are involved

QCD Matrix element :

$$< p' | \bar{\psi}_q(0) \; \mathcal{O} \; \psi_q(0) | p >$$

q : quark flavor (u,d,s)

ψ_q : quark field

Non Forwards: Initial (p) and final (P') 4 momentum are different for the nucleon

1. Hofstadter et al., time : 50's, Stanford electron accelerator predecessor of modern SLAC machine

Illustration of non local & non forward matrix element $< p' | \bar{\psi}_q(0) \mathcal{O} \psi_q(y) | p >$

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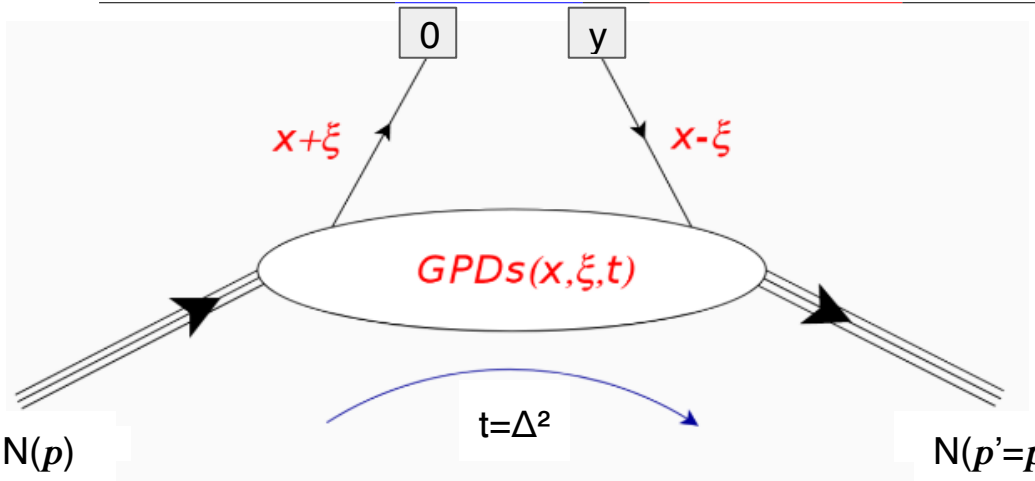

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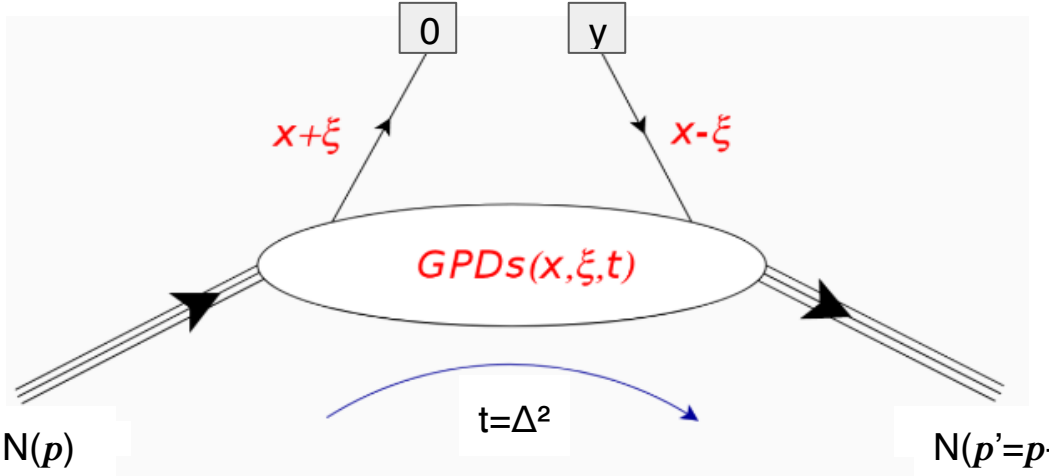
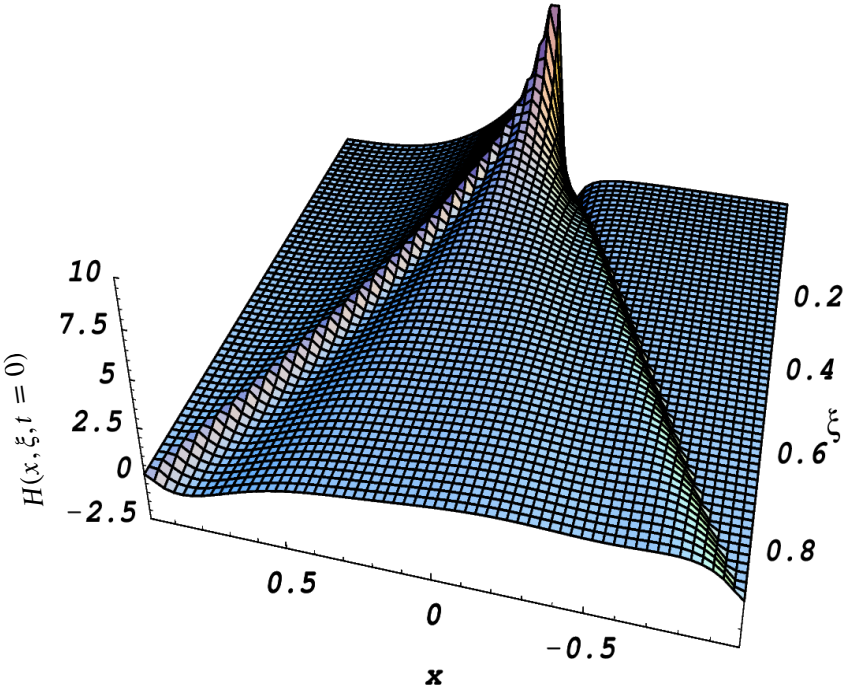


- P = (p+p')/2 : Average nucleon 4 momentum
- Δ = p' - p : 4 momentum transfer between final and initial nucleon
- t = Δ² : square of 4 momentum transfer between final and initial nucleon
- -2ξ : Purely longitudinal momentum transfer at quark level
- x+ξ : Positive momentum fraction (of P) carried by the initial quark
- x-ξ : Positive momentum fraction (of P) carried by the final quark going back to nucleon

Fourier Transform of vector & axial matrix element $< p' | \bar{\psi}_q(0)\ \mathcal{O}\ \psi_q(y) | p >$

$$H(x,\xi,t), E(x,\xi,t) \qquad \tilde{H}(x,\xi,t), \tilde{E}(x,\xi,t)$$

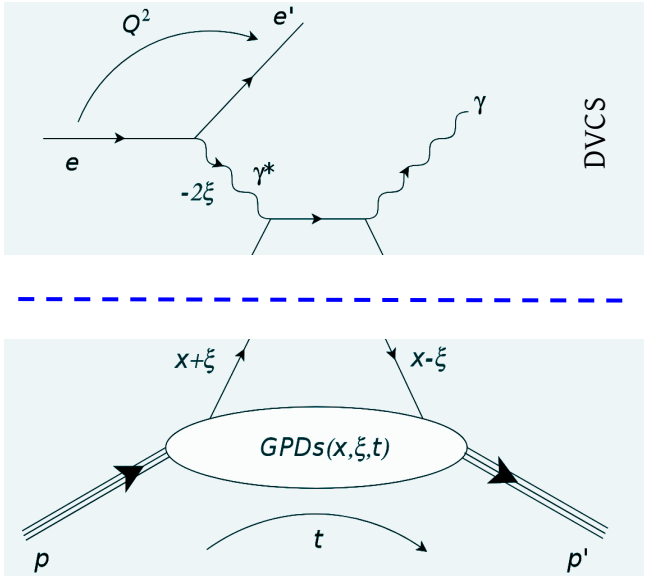


VGG model of GPD H as a function of x, ξ, t=0.

Q: How to access GPDs experimentally ?

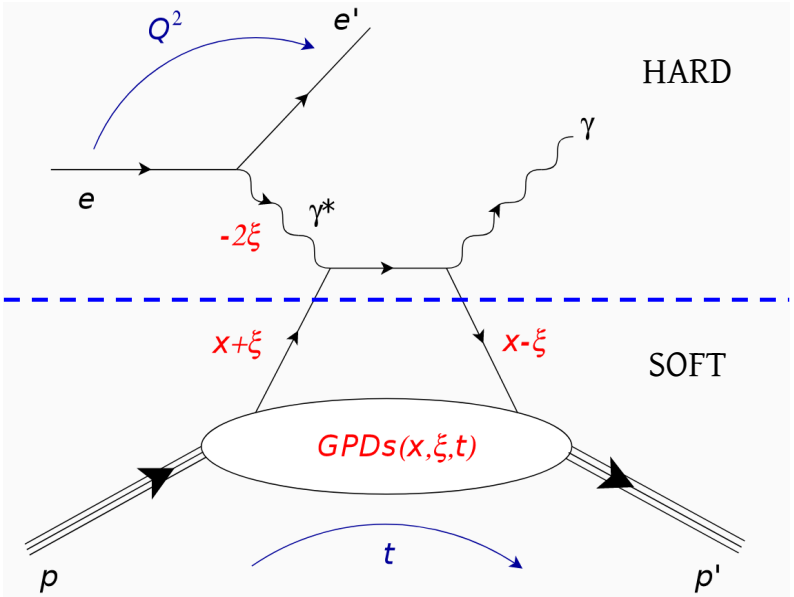
A : "Plug" a "Hard" process on the "Soft" process !

Provided the factorization is possible



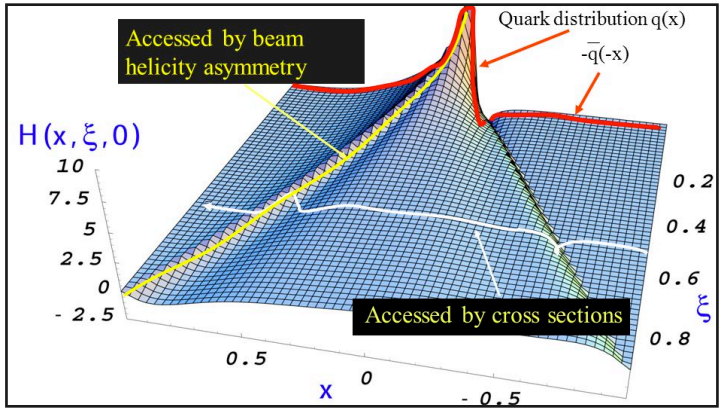
Accessing GPDs with experiments : "Plug" a "hard" process (e.g. DVCS)

The ξ, t are accessible through experiments but x is mute variable



Differential scattering Cross-section $\propto \left| \int_{-1}^{+1} dx \frac{H(x,\xi,t)}{x-\xi+i\epsilon} + \ldots \right|^2$

"..." Stand for the similar terms for $E, \tilde{E}, \tilde{H}$

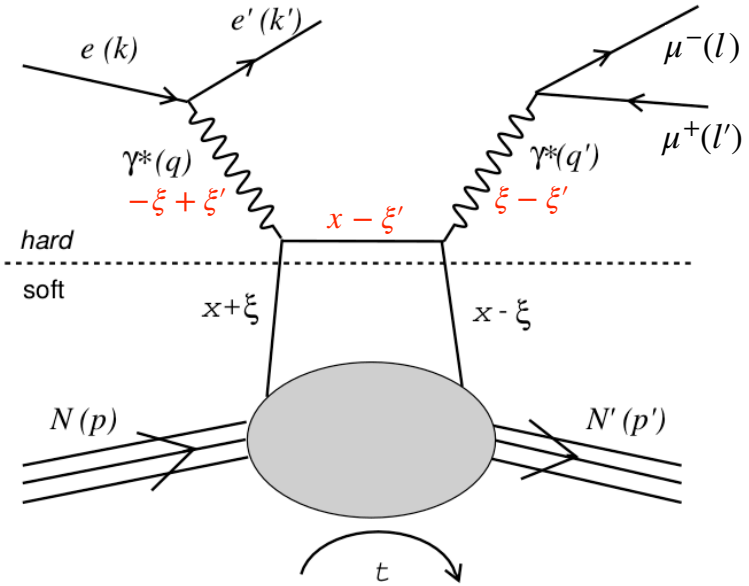


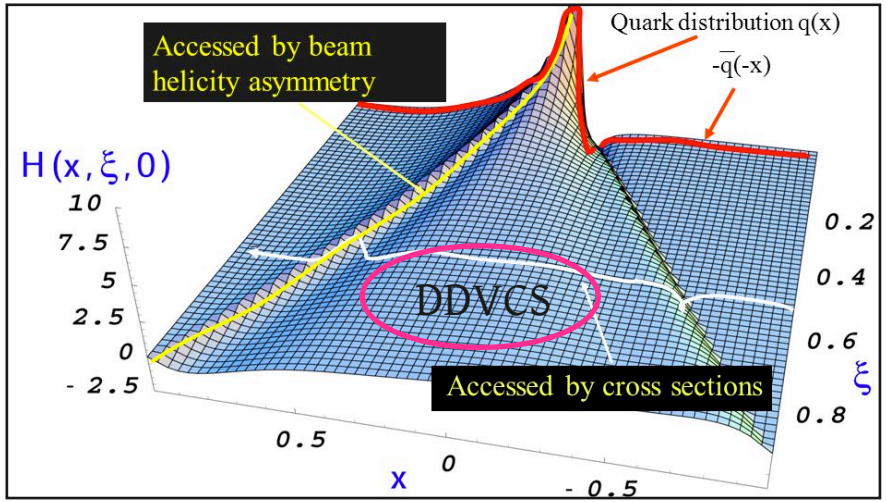
accessed by beam charge asymmetry in DVCS, but integrated over x

$$\int_{-1}^{+1} dx \frac{H(x,\xi,t)}{x \pm \xi + i\epsilon} + \ldots = PP\left(\int_{-1}^{+1} dx \frac{H(x,\xi,t)}{x \pm \xi} \right) - i\pi H(\pm\xi,\xi,t) + \ldots$$

The imaginary part of the amplitude can be accessed by beam spin asymmetry in DVCS, but at $x=\xi$

Accessing off-diagonal GPDs : "Plug" another "hard" process (e.g. DDVCS)





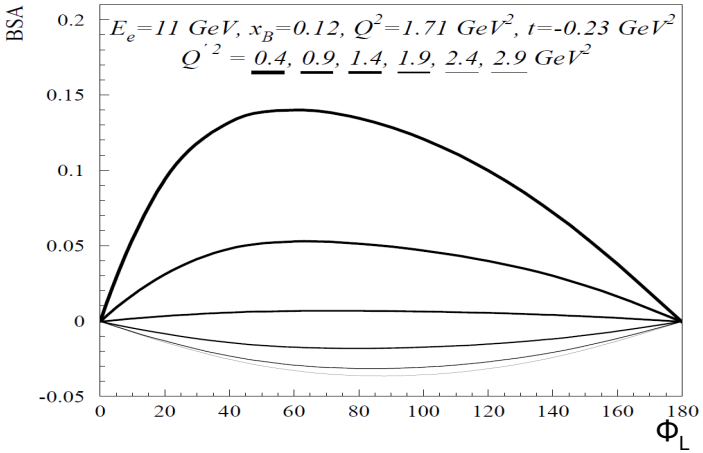
$$\int_{-1}^{+1} dx \frac{H(x,\xi,t)}{x-(2\xi'-\xi)+i\epsilon} + \ldots = PP\left(\int_{-1}^{+1} dx \frac{H(x,\xi,t)}{x-(2\xi'-\xi)}\right) - i\pi H(2\xi'-\xi,\xi,t) + \ldots$$

Observables for DDVCS measurements at JLab

Sign change in BSA and interplay “spacelike” “timelike” regions

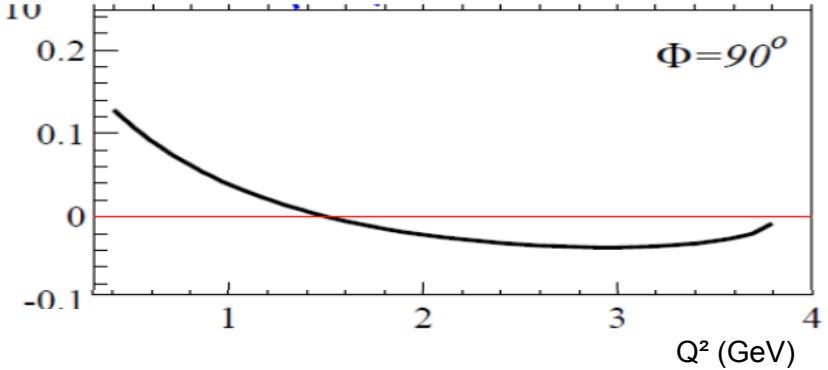
Calculations from M. Guidal

→ scan of BSA in Q'^2 at fixed Q^2



→ sign change in BSA vs Φ_L and vs Φ_{CM} when $Q'^2 \approx Q^2$

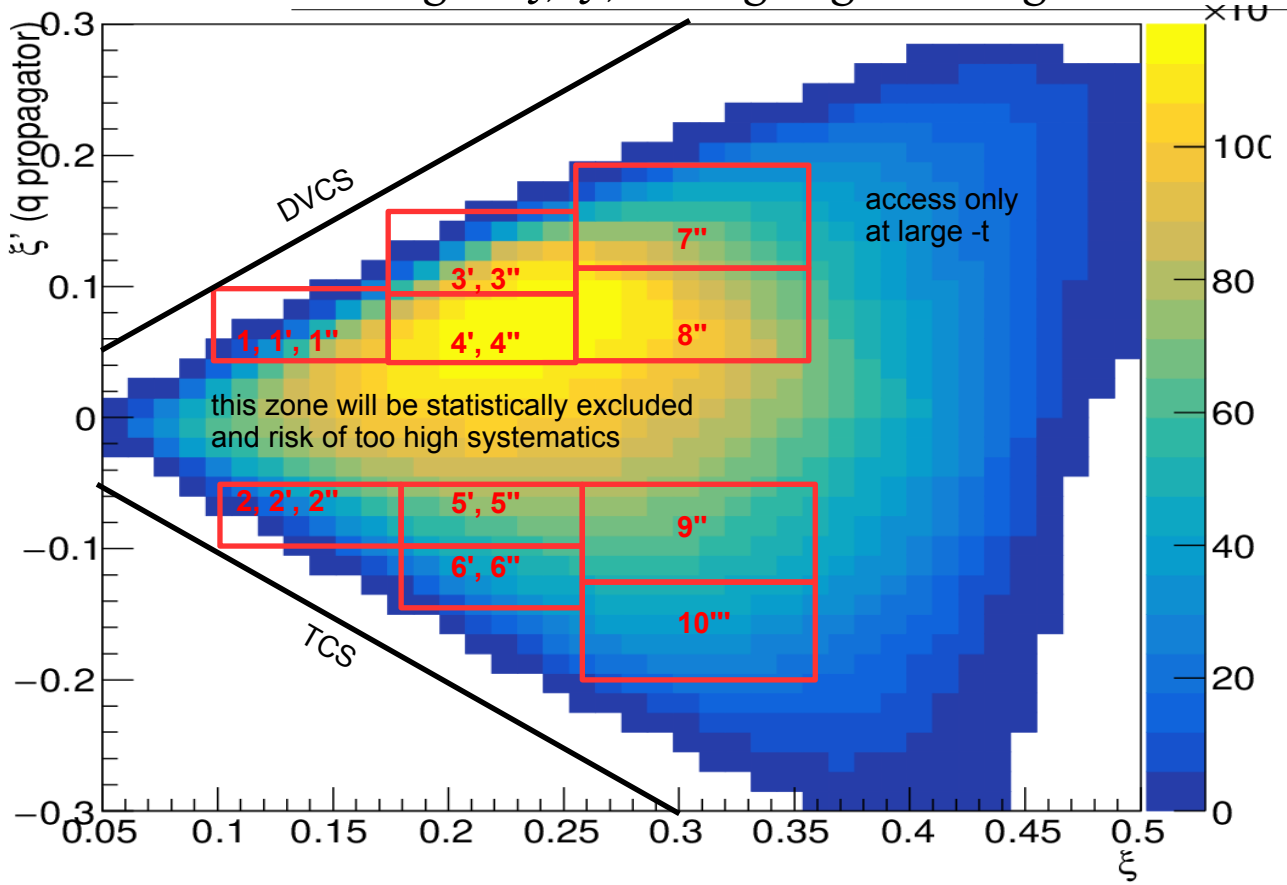
asymmetry Q^2 scan



- Probing GPDs at $x \neq \xi$ → tomographic interpretations....
- Expectation of sign change for observables sensitive to Im (DDVCS) when moving from « spacelike » to « timelike » region

→ this reaction is unique for probing effects between these 2 regions.

Binning in ξ, ξ', all t: going "off-diagonal" for tomographic views



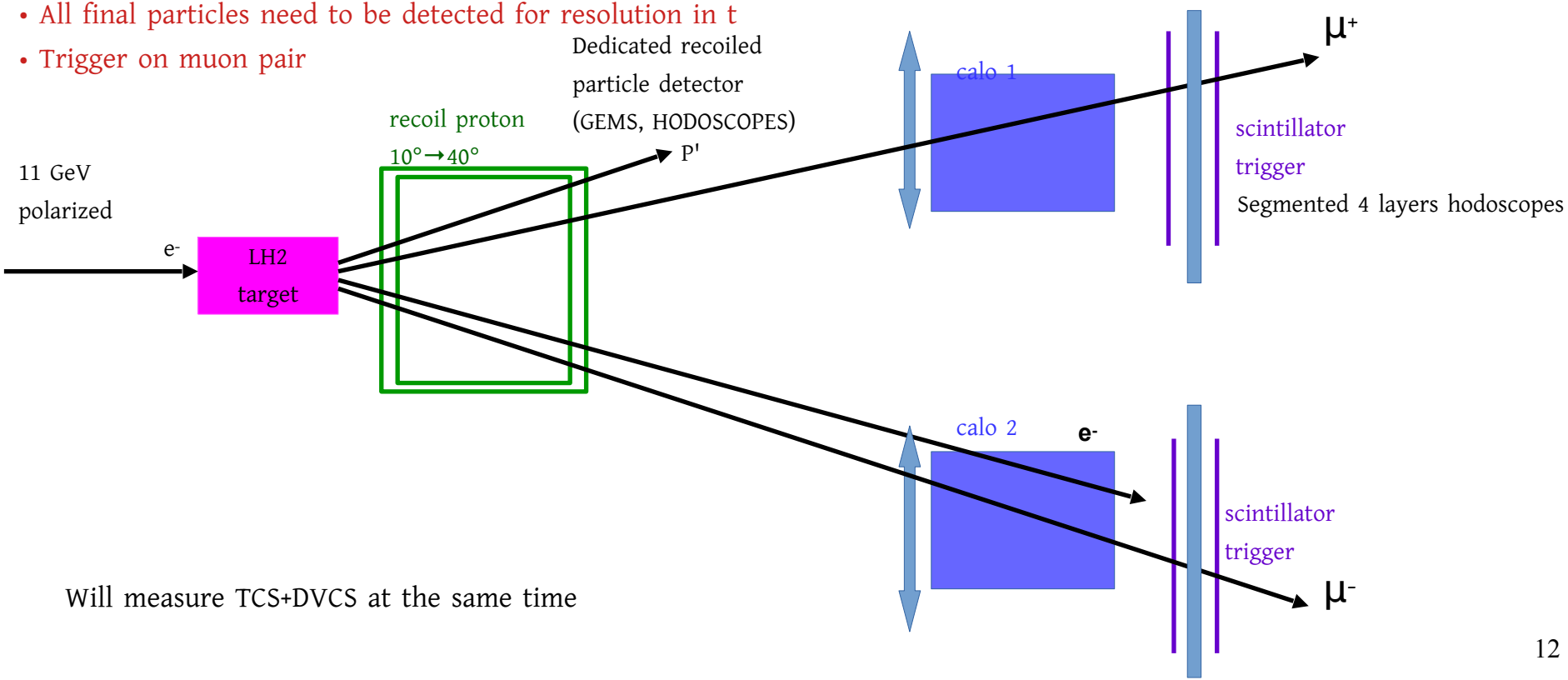
Bin in ξ	code #
A) .1 < ξ < .18	large/low t
(all t bins)	
1) .05 < ξ' < .1	1, 7, 17
2) -.05 > ξ' >-.1	2, 8, 18
B) .18 < ξ < .26	
(t bins 2 and 3)	
3) .1 < ξ' < .15	3, 9
4) .05 < ξ' < .1	4, 10
5) -.05 > ξ' > -.1	5, 11
6) -.1 > ξ' > -.15	6, 12
C) .26 < ξ < .36	
(t bin 3)	
7) .12 < ξ < .2	13
8) .05 < ξ < .12	14
9) -.05 > ξ > -.12	15
10) -.12 > ξ > -.2	16

Bins in t: (1) 0 < -t < 0.15 GeV², (2) 0.15 < -t < 0.35 GeV², (3) 0.35 < -t < 0.55 GeV² (indicated ', '')

From: M. Boer

Possible setup for DDVCS for in Hall C : setup 1: Extension of TCS setup

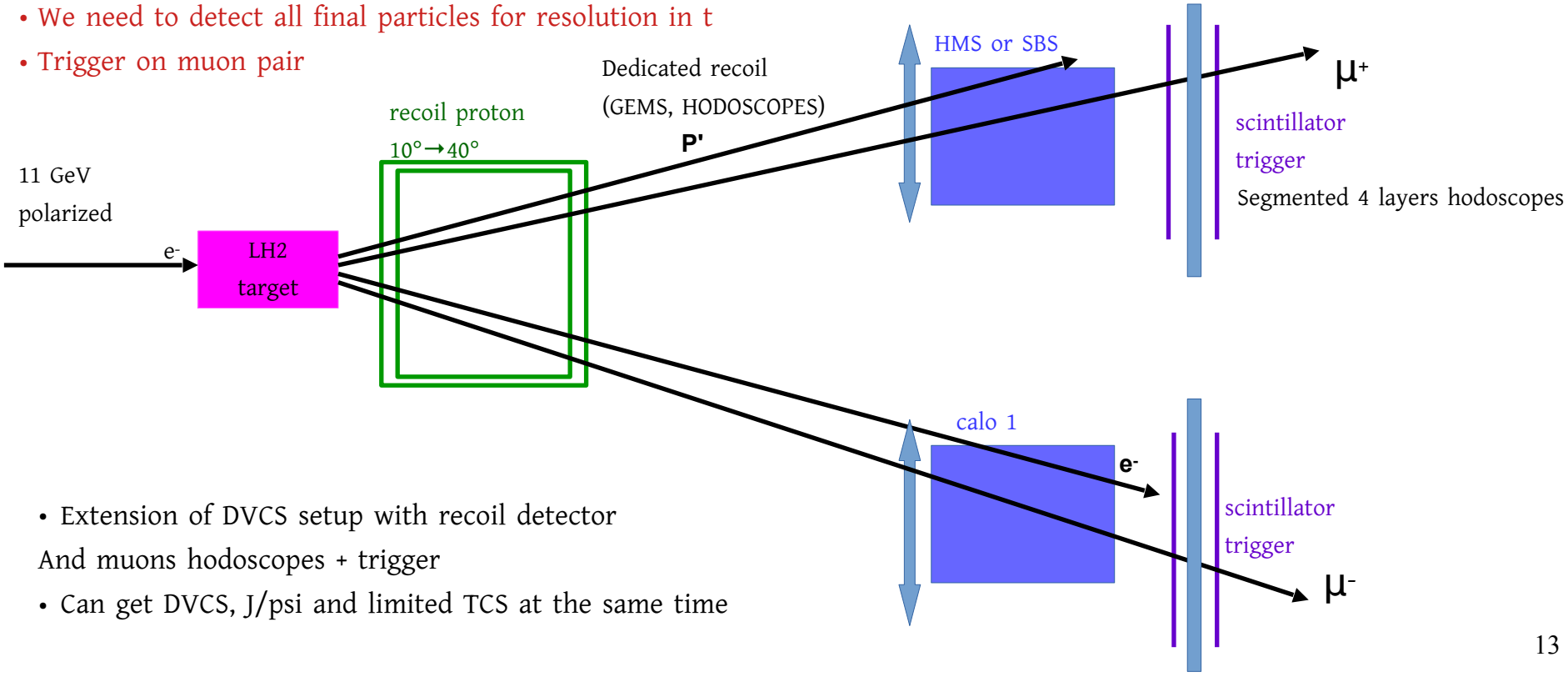
- Ideal detector position for different bins, assuming previous distributions "at vertex" are similar to the one with magnetic field
- Symmetric configuration for μ^+ and μ^- for better interpretation and treatment of BH2
- All final particles need to be detected for resolution in t
- Trigger on muon pair



Will measure TCS+DVCS at the same time

Possible setup for DDVCS for in Hall C : setup 2

- ideal detector position for different bins, assuming previous distributions "at vertex" are similar to the one with magnetic field
- symmetric configuration for μ^+ and μ^- for better interpretation and treatment of BH2
- We need to detect all final particles for resolution in t
- Trigger on muon pair



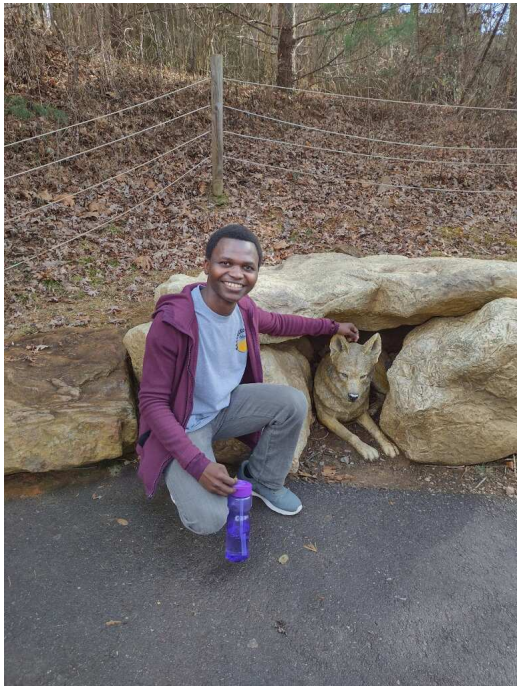
- Extension of DVCS setup with recoil detector

And muons hodoscopes + trigger

- Can get DVCS, J/psi and limited TCS at the same time

Hadron physics Lab (M.Boer's group) @ VT : building from ground up

Graduate Students



Gyang Chung

Mahmoud Gomina

Summary

- The physics case for the DDVCS is already proven very strong
- Measuring off-diagonal GPDs through experiment could be tricky
- Hardware wise immediate challenge is to check the feasibility of making a muon detector for Hall C
- Work is in progress for building the prototype
- Hope to answer more open ended questions by next meeting