# Challenges and Opportunities with Generalized Parton Distributions

- DVCS and Deep Virtual Meson Production (DVMP) measure GPDs on $x=\pm\xi$ line.
    - DDVCS and QCD Evolution give limited access to $|x|\neq\xi$
    - Angular momentum sum-rule at constant $\xi$
      and probability imaging at $\xi=0$ are not directly accessible experimentally.
- GPDs are the Twist-2 signal of DVCS and DVMP. How do we isolate this from higher twist (is $Q^2$-dependence enough?)
    - Higher twist contains important Quantum correlations!
- How can we determine the appropriate meson Distribution Amplitudes for evaluation of DVMP?: Asymptotic? Flat?
    - HERA data suggests factorization works for $Q^2 \sim 5$ GeV$^2$,
      but strong finite size corrections persist up to > 10 GeV$^2$

# SPATIAL IMAGING at $\xi=0$ and at $x=\xi$

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Informal Pre-Town Meeting at JLab

August 13 - 15, 2014

# Regge-Inspired Model

- M.Diehl, P. Kroll, *Eur.Phys.J. C***73** (2013) 2397.

    - $H_f(x,0,\Delta^2) = q_f(x) exp[\Delta^2 B_{1f}(x)]$
      $E_f(x,0,\Delta^2) = e_f(x) exp[\Delta^2 B_{2f}(x)]$

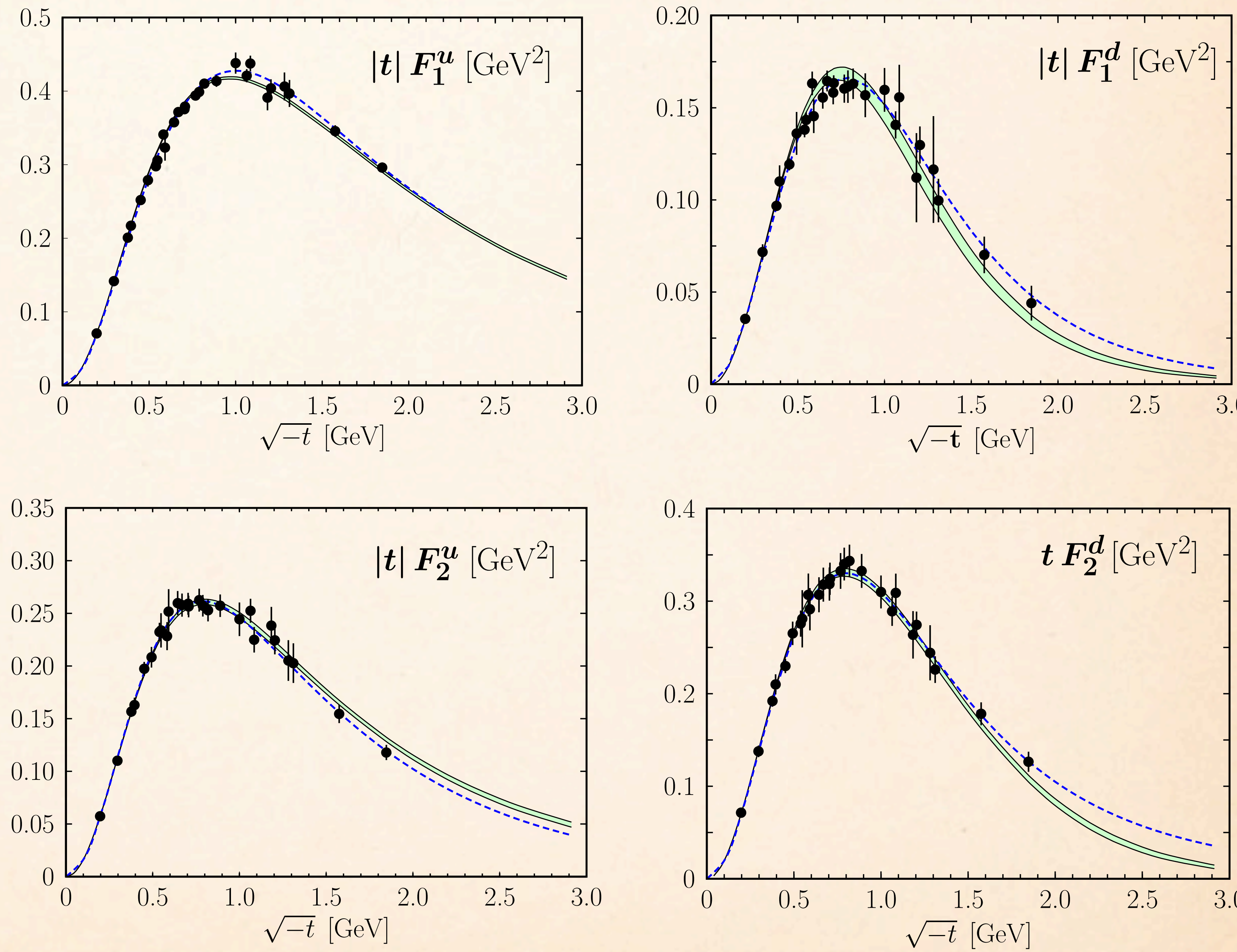
        - $q_f(x)$: *ABM2011*
          $e_f(x) = \kappa_f N_f\, x^{-\alpha f} (1-x)^{-\beta f} (1-\gamma_f\, x^{1/2})$

        - $B_{nf}(x) = \alpha_f' (1-x)^3 log(1/x) + A_{nf}\, x(1-x)^2 + B_{nf} (1-x)^3$

    - Fit:
      $\int dx\, H_f(x,0,\Delta^2) = F_{1f}(-\Delta^2)$
      $\int dx\, E_f(x,0,\Delta^2) = F_{2f}(-\Delta^2)$

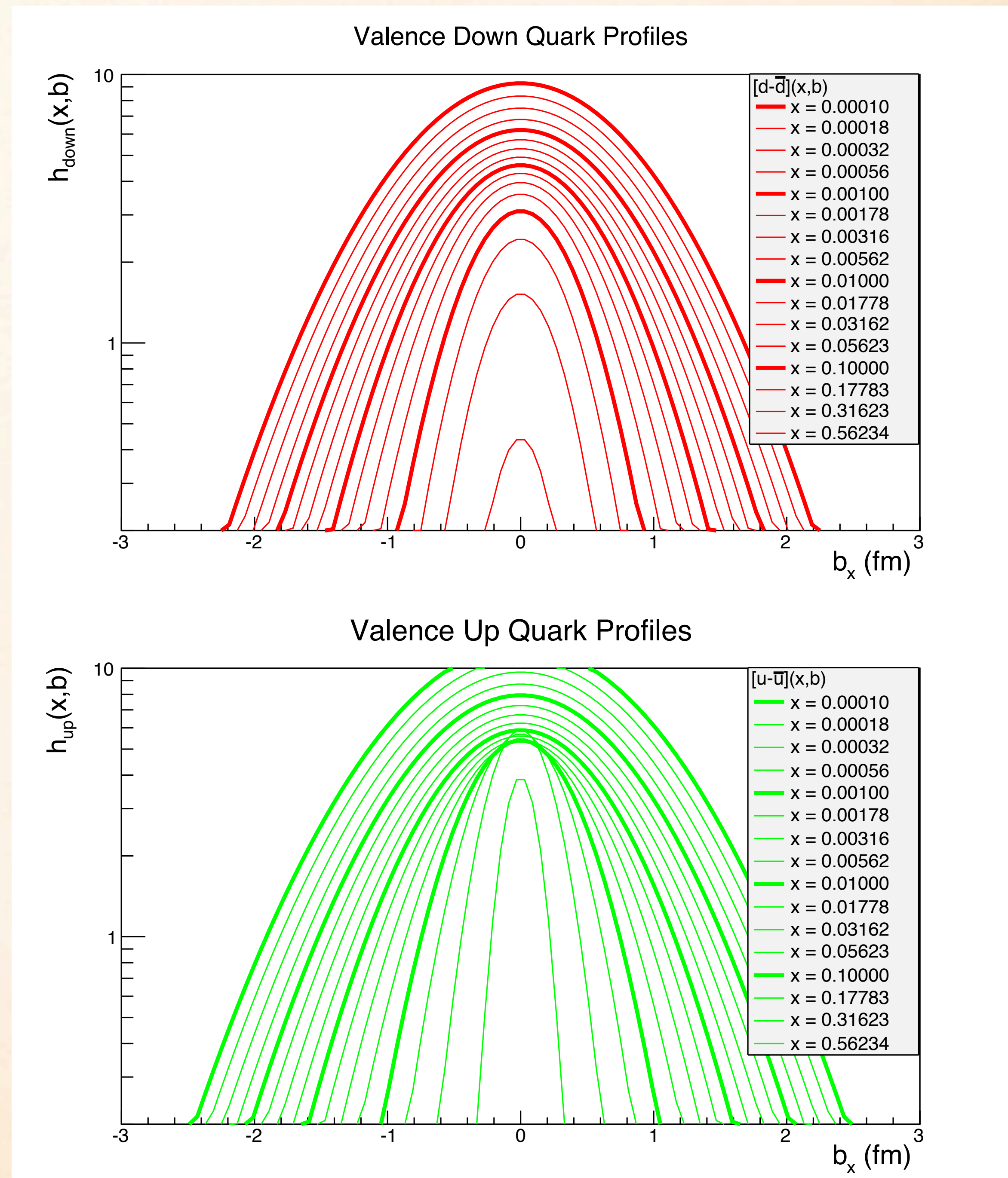
# Form Factor Fits

- Non-trivial $t$-dependence from $x$-dependent simple Regge slopes
- All the funny little wiggles in $G_{E,M}(-t)$ are resolved into a smooth behavior of the flavor separated $F_{1,2}$



# Spatial Densities at ξ=0

- *x*-dependent *t*-slope *B(x)*
    - Simple Gaussians in impact parameter space $(b_x, b_y)$
- Gaussian width strongly *x*-dependent
    - Negative charge density at center of neutron
- Scale: $\mu^2 = 2\ \mathrm{GeV}^2$.

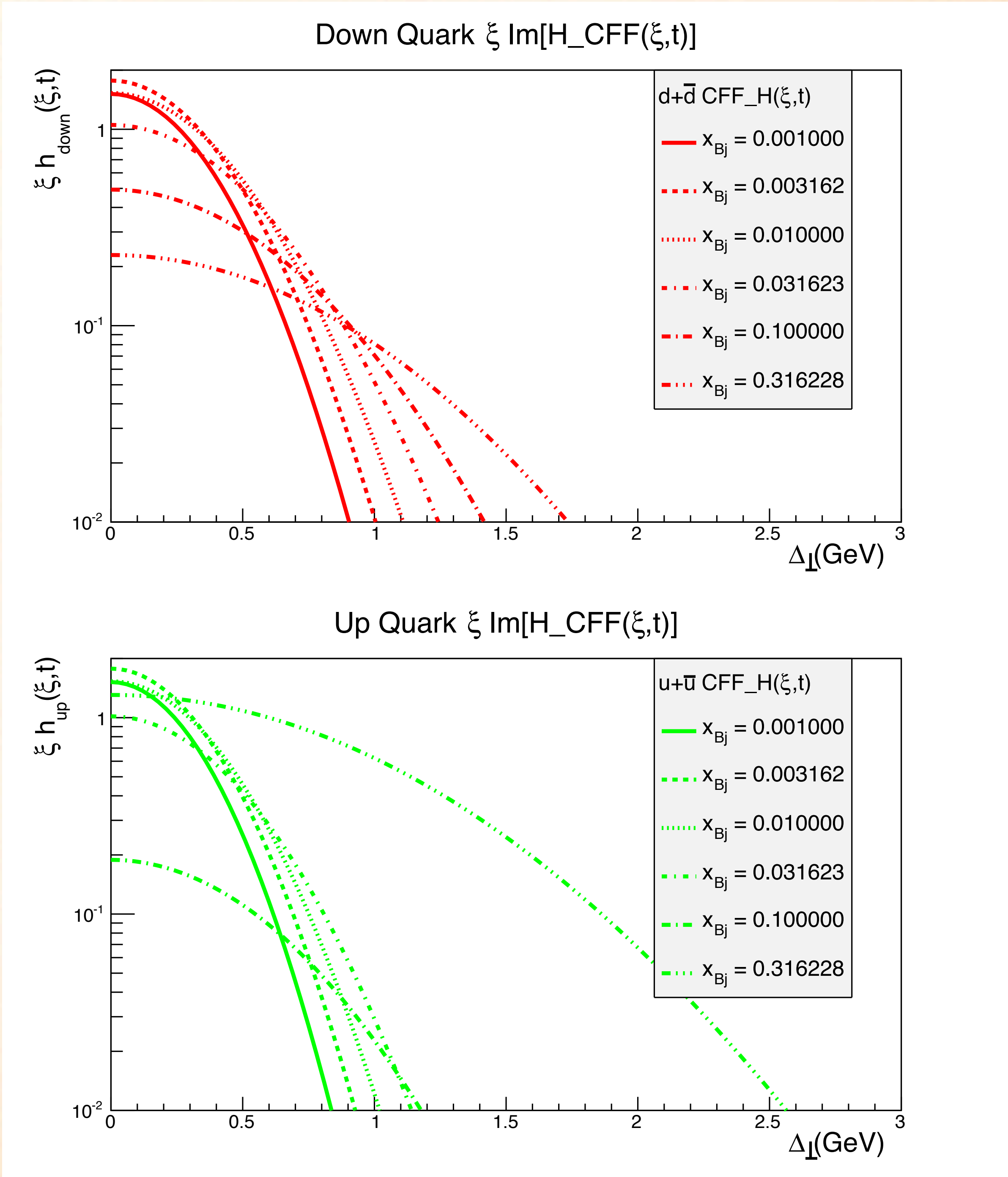


# Double-Distribution GPDs at $x=\pm\xi$

- Compton Form Factor: $\xi = x_{Bj}/(2-x_{Bj})$
  $Im[\mathcal{H}_f(\xi,\Delta^2)] = \pi[H_f(\xi, \xi, \Delta^2) - H_f(-\xi, \xi, \Delta^2)]$
- $$\xi\,\mathrm{Im}\left[\mathcal{H}_f\left(\xi,\Delta^2\right)\right] = \pi\int_0^{x_{Bj}} d\beta\left[q_f(\beta)+\bar{q}_f(\beta)\right]\left[h_f(\alpha,\beta)\right]_{\alpha=1-\beta/\xi} e^{\Delta^2 B_{1f}(\beta)}$$
- Profile functions $h(\alpha,\beta)$ arbitrary:
  - Use: $$h(\alpha,\beta) = N_1 \frac{\left[\left(1-|\beta|\right)^2 - \alpha^2\right]}{\left(1-|\beta|\right)^3}$$
- M. Burkardt, arXiv:0711.1881 $$\Delta^2 = -\frac{4\xi^2 M^2 + \Delta_\perp^2}{1-\xi^2}$$
  $\Delta_\perp$: Fourier Conjugate to $\mathbf{r}_\perp$, the transverse spatial separation between the active parton and the transverse spatial Center-of-Momentum of ***the spectator system***.

# Compton Form Factors on the $x=\pm\xi$ line

- Compton Form Factors:
  $x = \pm\xi$ profiles of GPDs:
- Radial size:
  strongly ξ-dependent
- Flavor, gluon variation is measureable
  - Intriguing insight into dynamics without sum-rules or extrapolation to ξ=0



# IMAGING


- In the Photoshop era, you don't have to be a Philosopher or a Surrealist to understand that the image of an object is **not** the object.
- $[H_f(\xi, \xi, \Delta^2) - H_f(-\xi, \xi, \Delta^2)]$ **is** an image of the proton.
  - It is a non positive-definite quantum transition density, but it still can be interpreted physically.